REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
1998

3. REPORT TYPE AND DATES COVERED
FY98 Annual Report

4. TITLE AND SUBTITLE
Assessment of Training Noise Impacts on the Red-Cockaded Woodpecker: Preliminary Results

5. FUNDING NUMBERS
N/A

6. AUTHOR(S)
Larry L. Pater, David K. Delaney, Timothy J. Hayden, Bernard Lohr, Robert Dooling

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Construction Engineering Research Laboratories
Champaign, IL

University of Maryland
College Park, MD

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

SERDP
901 North Stuart St. Suite 303
Arlington, VA 22203

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
N/A

11. SUPPLEMENTARY NOTES
FY98 Annual Report submitted to The Strategic Environmental Research and Development Program, SERDP Project No. CS-1083.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release: distribution is unlimited.

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 Words)*

This report is submitted as partial fulfillment of the terms of SERDP funded project CS-1083. The purpose of this research is to assess the effects of military training noise on the endangered Red-Cockaded Woodpecker (RCW) and to develop assessment methodology. The results of this research will provide scientific basis for RCW management protocols, and will partially satisfy requirements of a 1996 USFWS biological opinion that requires the Army to assess effects of implementing the 1996 "Management Guidelines for the RCW on Army Installations." Implementing these new guidelines will significantly reduce restrictions on training for military installations on which RCWs are present.

During the first year, we observed and documented several hundred training noise events and resulting RCW responses under realistic conditions. We measured both proximate response behavior and nesting success. We also observed RCW behavior and nesting success without noise stimuli, to provide a baseline against which to judge response and impact. Very few overt proximate responses to noise occurred. No significant difference in breeding success was found between disturbed and relatively uindisturbed nest sites. It is important to note that the first year data are not of sufficient statistical power to make strong conclustions or to establish reliable noise dose-response relations or thresholds. They are sufficient to confirm that the project technical approach is appropriate.

14. SUBJECT TERMS

red-cockaded woodpecker, RCW, SERDP, SERDP Collection, noise

15. NUMBER OF PAGES
96

16. PRICE CODE N/A

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
unclass.	unclass.	unclass.	UL

ASSESSMENT OF TRAINING NOISE IMPACTS ON THE RED-COCKADED WOODPECKER: PRELIMINARY RESULTS

Larry L. Pater
David K. Delaney
Timothy J. Hayden

U.S. Army Construction Engineering Research Laboratories
Champaign, IL

Bernard Lohr
Robert Dooling

University of Maryland
College Park, MD

FY98 (first year) Annual Report Submitted to
The Strategic Environmental Research and Development Program
SERDP Project No. CS-1083

Table of Contents

INTRODUCTION 3

- Executive Summary 3
- Background 3
- Objectives 4
- Mode of Technology Transfer 5

LITERATURE REVIEW 5

TECHNICAL APPROACH 7

- Scope 7
- Null Hypothesis 7
- Study Area 7
- Sample Cluster Selection 9
- Impact Measures 10
- Behavior and Proximate Response Measurement Protocols 11
- Demographic and Nesting Success Data 12
- Video Surveillance 12
- Sound Instrumentation and Recording 13
- Sound Metrics 14
- Statistical Data Analysis 15

RESULTS 16

- Initiation Dates for each Nesting Phase 16
- Overall Population Dynamics 16
- Sample Cluster Population Dynamics 16
- Noise and Response Monitoring Summary 17
- RCW Flush Response 18
- Distance and Noise Level Thresholds for Response 20

DISCUSSION 22

- Nesting Success 22
- Flush Response 22
- Distance and Sound Thresholds 22

PLANS 23

CONCLUSION 23

REFERENCES 24

- Biology 24
- Noise 26

APPENDIX A: WOODPECKER AUDIOGRAM CONTRACT REPORT 30

APPENDIX B: SUMMARY DATA TABLES 36

APPENDIX C: SOURCE SPECTRA EXAMPLES 42

APPENDIX D: SIGNIFICANT LEGAL REQUIREMENTS 52

APPENDIX E: DETAILED NOISE EVENT AND RCW RESPONSE DATA 54

INTRODUCTION

Executive Summary

This report is submitted as partial fulfillment of the terms of the Strategic Environmental Research and Development Program (SERDP) funded project CS-1083. The purpose of this research is to assess the effects of military training noise on the endangered Red-Cockaded Woodpecker (RCW) and to develop assessment methodology. The results of this research will provide scientific basis for RCW management protocols, and will partially satisfy requirements of a 1996 USFWS (U.S. Fish and Wildlife Service) biological opinion that requires the Army to assess effects of implementing the 1996 "Management Guidelines for the RCW on Army Installations." Implementing these new guidelines will significantly reduce restrictions on training for military installations on which RCWs are present. These include Ft. Stewart, Ft. Bragg, Ft. Benning, Ft. Polk, Ft. Gordon, Ft. Jackson, Camp Lajeune, Eglin AFB, and Camp Blanding. This research is being conducted jointly by USACERL (U.S. Army Construction Engineering Research Laboratories), Ft. Stewart and U.S. Army Forces Command (FORSCOM). The project was developed by USACERL in coordination with FORSCOM, USFWS RCW Recovery Coordinator and Region 4 office, Ft. Stewart Director of Training, Ft. Stewart DPW Fish and Wildlife Branch, and the Army TES User Group.

During the first year, we observed and documented several hundred training noise events and resulting RCW responses under realistic conditions. We measured both proximate response behavior and nesting success. We also observed RCW behavior and nesting success without noise stimuli, to provide a baseline against which to judge response and impact. Very few overt proximate responses to noise occurred. No significant difference in breeding success was found between disturbed and relatively undisturbed nest sites. It is important to note that the first year data are not of sufficient statistical power to make strong conclusions or to establish reliable noise dose-response relations or thresholds. They are sufficient to confirm that the project technical approach is appropriate and needs only minor revision, and that the project objectives will be achieved.

Background

The Endangered Species Act mandates all federal agencies to carry out programs to conserve threatened and endangered species (TES) and to evaluate the impacts of their activities on listed species (Scott et al. 1994). TES management on military installations, particularly involving RCWs, has caused conflicts between TES conservation objectives and military mission accomplishment (Fort Stewart ESMP 1998). A brief summary of legal requirements is presented in Appendix D. Because noise management has traditionally focused mainly on minimizing human annoyance, loud activities have often been relocated to sparsely populated areas where wildlife resides. This has led to increased interactions between training activity and wildlife (Holland 1991). Increasing importance has been placed on determining the extent of noise impacts on wildlife (Bowles 1995), especially threatened and endangered (Delaney et al. 1999).

The Red-cockaded Woodpecker (*Picoides borealis*; RCW) is an endangered species that inhabits mature, open pine forests of the southeastern United States (Jackson 1994). Historically, RCW populations were distributed throughout the South from eastern Texas to the Atlantic coast, and north to New Jersey (Jackson 1987). The distribution has been reduced with the extirpation of RCWs from New Jersey (Lawrence 1867), Missouri (Cunningham 1946 as cited in Jackson 1987), and most recently Maryland (Devlin et al. 1980). The majority of RCWs are currently restricted to public lands, namely National Forests, military installations, and National Wildlife Refuges (Jackson 1978,

Lennartz et al. 1983). Military installations, in particular, are gaining recognition as a valuable resource in the recovery of TES. It has been estimated that nearly a quarter of the remaining RCWs are located on nine military installations in the southeast (Costa 1992), which includes the Ft. Stewart population. Such a close association has led to increased conflicts between TES conservation requirements and the military's mission of maintaining a high degree of combat readiness (Jordan 1995).

In 1984 the Army initially established a 200 foot buffer zone around all RCW cavity trees to protect nesting habitat and identify RCW management units. In 1996, the Department of the Army (DA) issued revised guidelines for the management of RCWs on military lands, to reduce training restrictions and increase adaptive management of the RCW and its habitat. These guidelines are scheduled to go into effect by mid-1999. Under the revised guidelines, certain transient military activities are permitted within 50 feet of RCW cavity trees. These include: (1) military vehicle and personnel travel, including armor; (2) .50 caliber machine gun blank fire and 7.62 mm blank fire and below; (3) artillery/hand grenade simulators and Hoffman type devices; (4) hand digging of hasty individual fighting positions; (5) use of smoke grenades and star cluster/parachute flares; and (6) smoke and haze operation (see Hayden 1997 for a more detailed description of past and current Army guidelines for RCWs). It is estimated that the proposed revisions would reduce training restrictions on Ft. Stewart by 10-20% (T. Beaty, pers. comm.). A 1996 USFWS biological opinion requires the Army to assess effects due to implementing the 1996 guidelines. The current project will provide an important aspect of this required assessment.

The Ft. Stewart Fish and Wildlife Directorate prepared an Endangered Species Management Plan (ESMP 1998) for the installation that detailed four main changes under these revised guidelines: 1) consideration will be given jointly to training mission requirements and RCW biological requirements when implementing ESMP; 2) no training restrictions will be imposed on any new RCW clusters; 3) reduction in off-limit area for thru-cluster maneuver traffic around cluster trees from 200 feet. to 50 feet; and 4) the types of training activities allowed within RCW clusters will be expanded. These revisions are scheduled to go into effect by mid-1999.

Objectives

The primary research objective of this study is to determine the impact of certain types of training noise on the endangered Red-cockaded Woodpecker (RCW). This will require that we develop dose-response threshold relationships for quantifying RCW responses to noise levels and stimulus distances, and relate these to nesting success. A second objective is to develop and disseminate cost-effective techniques for documenting the effects of training noise on TES populations. These techniques include the capability to characterize noise stimuli, to document behavioral responses, and to determine resulting population effects due to military noise. Achieving these objectives will provide means to manage impact on both military training capability and TES, and will provide factual basis for mitigation and management protocols and guidelines. This research directly addresses the #1 Army Conservation Pillar User Requirement, impacts of military operations on threatened and endangered species (TES). The results of this research will partially satisfy requirements of the 1996 USFWS biological opinion (Jordan et al. 1997) that requires the Army to assess effects due to implementing the 1996 "Management Guidelines for the RCW on Army Installations."

Mode of Technology Transfer

Products of this research will be provided directly to the Military Services for use during consultation with the USFWS and for development of management protocols. This aspect of the transition plan will directly help to alleviate impacts on military training capability and will provide information to the military that will guide effective management of impacts on endangered species populations. Other vehicles will include technical papers and journal articles and TES and noise workshops. The information will also be disseminated through the Environmental Noise Program Office of the U.S. Army Center for Health Promotion and Preventive Medicine, the Army TES User Group, and the USAF International Bibliography on Noise (IBON). Other forums for dissemination include the NATO CCMS subcommittees for noise effects, the International Committee on the Biological Effects of Noise (ICBEN), the Acoustical Society of America Animal Bioacoustics technical committee, and the DoD Committee on Environmental Noise.

LITERATURE REVIEW

Noise disturbance studies have often been anecdotal in nature and fail to quantitatively measure either the stimulus or the behavioral response related to the animal's fitness. Predictive models for the relationship between disturbance dosage and quantifiable effects are even more scarce (Awbrey and Bowles 1990, Grubb and King 1991, Grubb and Bowerman 1997). Although many types of human disturbance have been reported as impacting birds (Fyfe and Olendorff 1976), very little research has addressed the effects of human activity on woodpeckers, especially the endangered Red-cockaded Woodpecker (Charbonneau et al. 1983, Jackson 1983, Beaty 1986, and Jackson and Parris 1995, TNC 1996).

Few researchers have directly compared differences in bird responsiveness between aerial and ground-based disturbances (Bowles et al. 1990). Studies that have examined the effects of aircraft activity on nesting birds (e.g., Platt 1977, Windsor 1977, Ellis 1981, Anderson 1989) have often noted a slight but non-significant decrease in nesting success and productivity for disturbed versus undisturbed nests. Anderson et al. (1989) noted a slight decline in the nesting success of experimental Red-tailed Hawk (*Buteo jamaicensis*) nests versus control nests (80% versus 86% success) after helicopter disturbances.

In contrast, ground-based disturbances appear to have a greater impact than aerial disturbances on the nesting success of some bird species. In their classification tree model of Bald Eagle (*Haliaeetus leucocephalus*) responses to various anthropogenic disturbances, Grubb and King (1991) determined that Bald Eagles in Arizona showed the highest response frequency and severity of response towards ground-based disturbances, followed by aquatic, and lastly by aerial disturbances. Delaney et al. (1999) reported similar findings for Mexican Spotted Owl (*Strix occidentalis lucida*) response to military helicopter activity and chain saws, observing that chain saws elicited a greater flush response rate than helicopters at comparable distances and noise levels.

A bird's behavior during the nesting season is an important determinant of its ultimate nesting success or failure (Hohman 1986). Various bird species have been shown to abandon their nests after being exposed to ground-based and aerial disturbances. White and Thurow (1985) reported that approximately 30% of Ferruginous Hawks (*Buteo regalis*) abandoned their nests after being exposed to various ground-based disturbances, but there were no controls for comparison. Anderson et al. (1989) reported that two of 29 Red-tailed Hawk nests were abandoned after being flushed by

helicopter flights, compared with zero of 12 control nests. Ellis et al. (1991) found only one of 19 Prairie Falcon (*Falco mexicanus*) nests were abandoned when exposed to frequent low-altitude jet flights during the nesting season (no control sites utilized). Platt (1977) reported similar rates with only one of 11 Gyrfalcon (*F. rusticolus*) nests failing (reportedly due to snow damage), compared with zero of 12 control nests. Of the six Peregrine Falcon (*F. Peregrinus*) nests exposed to helicopter flights, only one was abandoned (also apparently due to inclement weather) compared with zero of three control sites (Windsor 1977).

Birds may be more susceptible to disturbance-caused nest abandonment early in the nesting season because parents have less energy invested in the nesting process (Knight and Temple 1987). Some animals appear reluctant to leave the nest later in the nesting season (Anderson et al. 1989, Ellis et al. 1991, Delaney et al. 1999). Steenhof and Kochert (1982) reported that Golden Eagles (*Aquila chrysaetos*) and Red-tailed Hawks exposed to human intrusions during early incubation had significantly lower nesting success than individuals exposed later in the season (45% success for Golden Eagles and 57% for Red-tailed Hawks within experimental groups versus 71% and 74% success with control groups, respectively). Although reactions of adult birds at the nest can influence hatching rates and fledgling success (Windsor 1977), flush behavior of adult birds from the nest is poorly quantified (Fraser et al. 1985, Holthuijzen et al. 1990, Delaney et al. 1999). In the few studies that have examined bird responses to specific disturbance types (e.g., aircraft approach distance), flush rates were higher if birds were naive (i.e., not previously exposed; Platt 1977). Some birds are more reluctant to flush off the nest during incubation and early nestling phases than later in the season (Grubb and Bowerman 1997, Delaney et al. 1999). Animal responsiveness has been shown to increase as the nesting season progresses (Grubb and Bowerman 1997). Delaney et al. (1999) found that Mexican Spotted Owls were more responsive to helicopters later in the reproductive cycle which suggests that adult defensive behavior may decrease as young mature. In contrast, Holthuijzen et al. (1990) found Prairie Falcon responsiveness to nearby blasting activity decreased as the nesting season progressed.

Few studies have documented the threshold distance that causes birds to flush in response to noise disturbance events. In those studies that reported stimulus distance, it was rare for birds to flush when stimulus distance was > 60 m (Carrier and Melquist 1976, Edwards et al. 1979, Craig and Craig 1984, Delaney et al. 1999). Similar findings were reported by Carrier and Melquist (1976) for Osprey (*Pandion haliaetus*), and Ellis (1981) for Peregrine Falcons. Many disturbance study reports imply that animal response increases with decreasing stimulus distance (Platt 1977, Grubb and King 1991, McGarigal et al. 1991, Stalmaster and Kaiser 1997), though few studies have experimentally tested this relationship (see Delaney et al. 1999). Delaney et al. (1999) found that the proportion of owls flushing in response to a disturbance was strongly and negatively related to stimulus distance and positively related to noise level.

Even fewer examples are available for noise response thresholds. Snyder et al. (1978) reported that Snail Kites (*Rostrhamus sociabilis*) did not flush even when noise levels were up to 105 dBA from commercial jet traffic. This result was qualified by the fact that test birds were living near airports and may have habituated to the noise. Edwards et al. (1979) found a dose-response relationship for flush responses of several species of gallinaceous birds when approach distances were between 30-60 m and noise levels approximated 95 dBA. Delaney et al. (1999) reported that Mexican Spotted Owls did not flush during the nesting season when the SEL noise level for helicopters was ≤ 92 dBA and the LEQ level for chain saws was ≤ 46 dBA. Noise response thresholds were fairly

comparable with data from the non-nesting season (92 dBA for helicopters and 51 dBA for chain saws).

Distance has been described as the most commonly used surrogate for noise disturbance in the animal effects literature, and has been proposed to be the best representative for quantifying the relationship between stimulus and response measures (Awbrey and Bowles 1990). The reason appears to be that distance is more conveniently implemented into management practices (i.e., establishment of buffer zones) than other variables. However, use of properly measured noise level as the stimulus measure facilitates broader application of response results, in particular to sources of similar aural character but different acoustic power emission.

TECHNICAL APPROACH

Scope

The scope of this research is to assess the effects of military training noise on the RCW population on Ft. Stewart, Georgia, by direct observation of RCW behavior and nesting success. All aspects of the research plan were reviewed and approved by the USFWS and Ft. Stewart before monitoring activity began. Results from this research apply directly to Ft. Stewart, and may also be applicable to other installations in the southeastern U.S. where RCWs and similar noise occur. This study will utilize population data collected at Ft. Stewart and other installations under a leveraged FORSCOM program. Specific evaluation of impact of maneuver training activities will be conducted under a separate coordinated research effort.

Training noise sources examined during this study include large caliber live fire, small arms live fire, small arms blank fire and artillery simulators, and helicopter flights. RCW response to other military activity noise, such as human and vehicle noise associated with maneuver training, aircraft overflights, and MLRS fire, will be documented opportunistically, but is not of high priority in this study.

Null Hypothesis

Data collection, summary, and statistical analyses to assess and to characterize military training noise in RCW clusters, and to evaluate the relationship between noise levels and RCW demographic data, are based on the following formal null hypotheses:

I. Ho: There is no difference in the nesting success, productivity, or nesting behavior between disturbed and undisturbed RCW nest sites.

2. Ho: There is no relationship between stimulus distance or noise level and RCW response behavior.

3. Ho: There is no difference in RCW response between types of training activities.

Study Area

Ft. Stewart is located in east-central Georgia (Figure 1) within Liberty, Long, Bryon, Tattnall, and Evans counties, and is the largest Army Installation east of the Mississippi River. Physiographically, this area lies within the Atlantic Coastal Flatwoods Province (USDA SCS 1980), within a humid, semi-tropical latitude, and averages 50 inches of rain a year. The average temperature in January is 62 F with a relative humidity of 70%, while July averages 91 F with a relative humidity of 76% (National Weather Service). Approximately 66% of the 112,745 ha of the installation are

terrestrial and cover three main forest types: upland pine stands composed primarily of longleaf (*Pinus palustris*), loblolly (*P. taeda*), and slash pine (*P. elliottii*); mixed pine-hardwood sites; and hardwood stands. The remaining habitats include various wetland types and open water (ESMP 1998).

The primary mission of Ft. Stewart is training and operational readiness of the 3rd Infantry Division (Mech.) and other non-division units. The 3rd Infantry Division (previously the 24th) was activated in 1975 and re-designated as a mechanized division in 1979 (Hayden 1997). Training activities are conducted year-round at Ft. Stewart to maintain a combat ready fighting force. The installation also supports training of regional National Guard and Reserve units, as well as joint training exercises with troops from other installations and DoD Branches (Fort Stewart ESMP 1998).

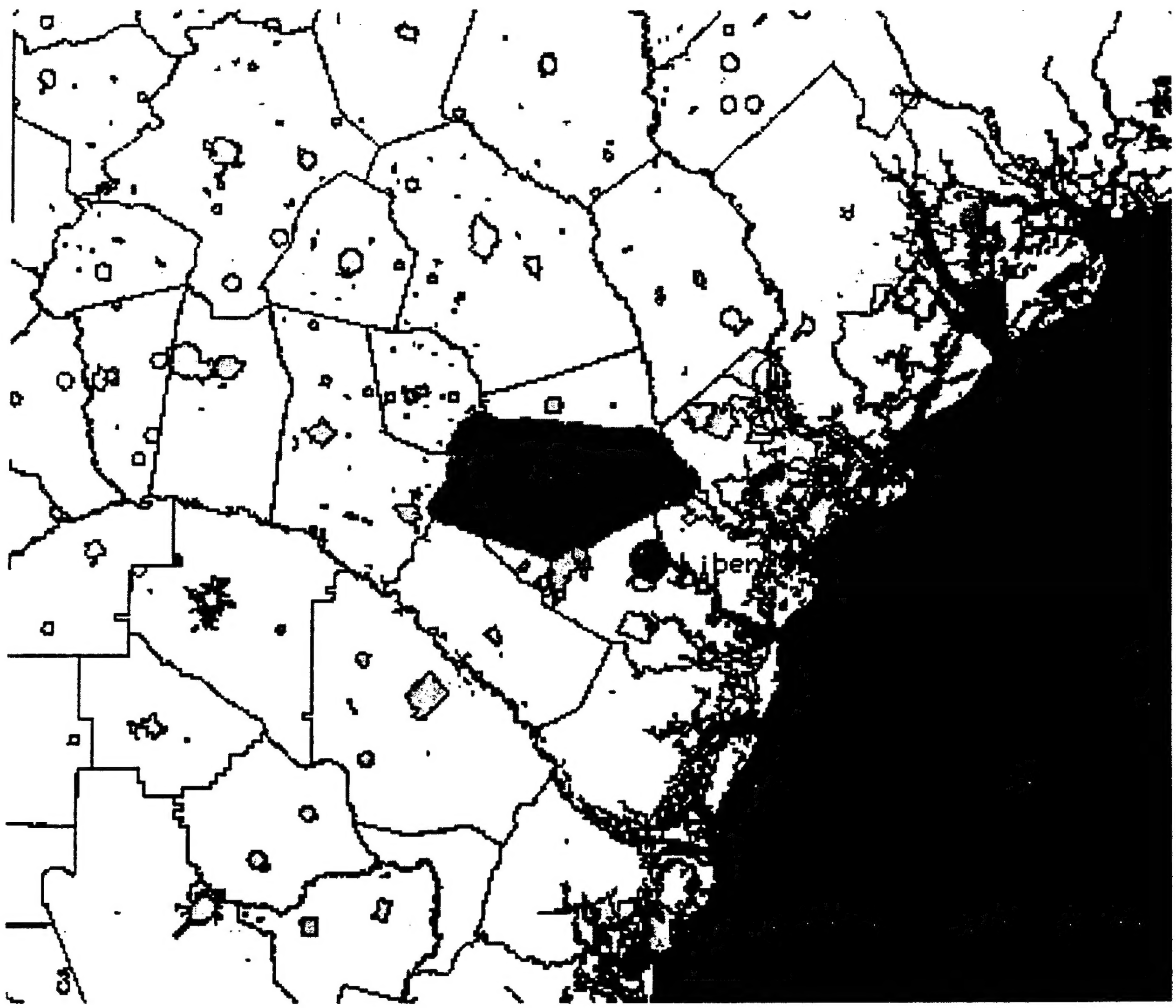

Figure 1. Location of Ft. Stewart Army Installation within the state of Georgia.

Ft. Stewart contains a variety of impact and firing areas, as is shown in Figure 2. The central feature of the installation is the Artillery Impact Area (AIA; ~ 5,200 ha) which is surrounded by dozens of artillery firing points varying in distance from a few hundred meters to thousands of meters from the impact area itself. On the western border of the AIA is the Red Cloud Multipurpose Range Complex (MPRC) containing eight separate ranges. Just south of the AIA is the Explosive Ordnance Disposal Area (EOD), the Demolition Area (DEMO), and the Small Arms Impact Area (13 live-fire ranges, ~ 2,300 ha). To the east and northeast of AIA are the Calfax and Luzon Ranges, and three smaller Aerial Gunnery Ranges (AGR). There are also seven drop zones located throughout the installation (Hayden 1997).

Ft. Stewart Special Purpose Areas

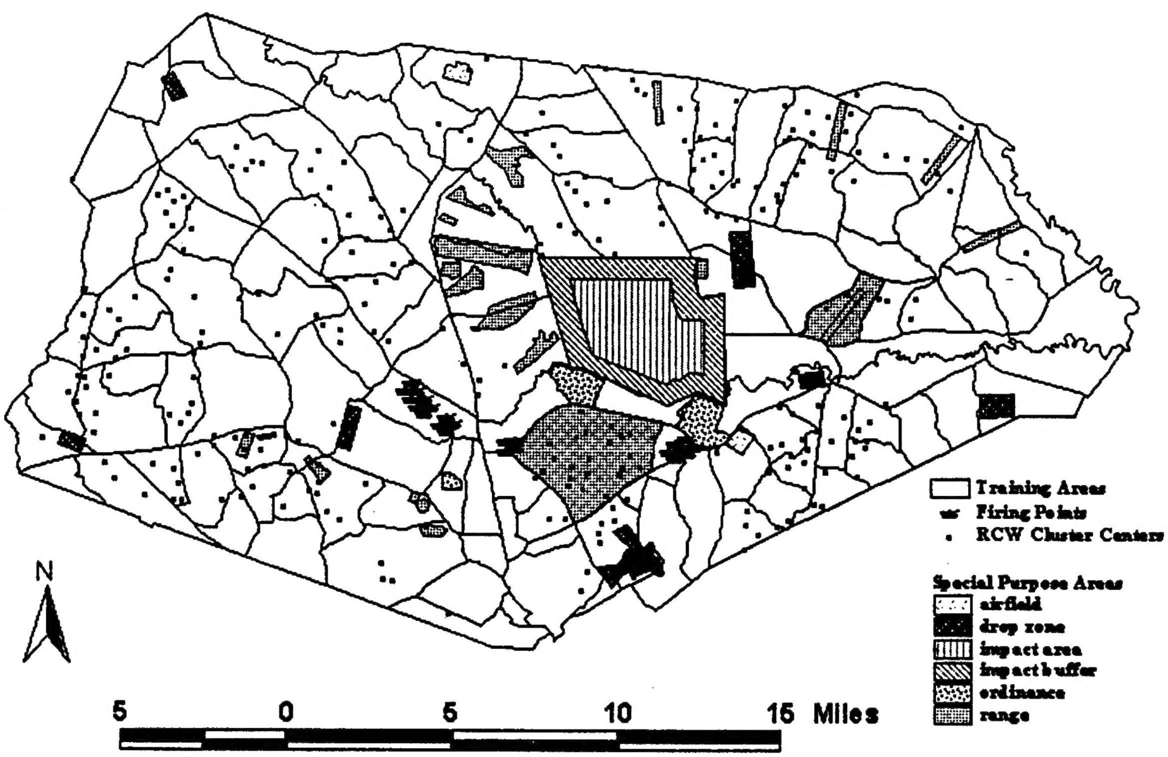

Figure 2. Locations of military training areas and RCW clusters on Ft. Stewart.

Sample Cluster Selection

There are approximately 270 known RCW cavity tree clusters on Ft. Stewart, distributed as shown in Figure 2. None are known in the AIA because this area cannot be safely surveyed. Of the approximately 141 reproductively active (mated pair present) RCW clusters, we chose 50 sample clusters for observation during the first field season. We intend to use these same clusters insofar as practical throughout this multiyear study. We classified clusters according to type and level of training noise, based on the number, distance, and noise levels of stimulus events that, to the best of our knowledge, each cluster typically receives. Three types of sample sites were chosen: passive

disturbed, undisturbed and experimental. "Passive disturbed" sites were sites that receive potentially significant noise disturbance as part of normal training operations; we had no direct control over time, number or level of noise events at these sites. Noise types include large caliber live fire, small arms live fire, artillery simulators, and helicopter flights. We attempted to choose sites that received predominantly only one type of noise, but this was sometimes impossible if we were to also utilize the highest noise level clusters. "Undisturbed" or "low disturbance" sites (the two terms are equivalent and are used interchangeably in this report) are sites where noise levels were judged likely to be consistently low or absent for all of the noise types. At these sites we observed behavior and measured nesting success as a baseline for judging impact at disturbed sites. It is likely that at least some level of military noise of some type can be perceived at every RCW cluster on Ft. Stewart. Our criterion for low disturbance is noise levels near or below ambient noise levels. At "experimental" sites we exposed the birds to small arms blank fire under controlled conditions. The experimental sites were chosen from among cluster sites that had otherwise low noise disturbance. This implies that birds at these sites were not habituated to the noise stimulus. The sample clusters were randomly selected within noise types. Sample size was limited by the number of clusters that fit each of the foregoing selection protocol criteria and by available field observation resources.

Impact Measures

Selection of noise impact criteria is a critical issue. For humans the response criterion is typically annoyance. For domesticated species the issue may be damage to individual animals or impacts on profits. For TES, the ultimate concern is long-term survival of the species. The challenge is to develop a relatively short-term procedure for inferring impact on long-term survival. The conceptual approach that will be used in this study is depicted in Figure 3. First, proximate responses to the noise stimulus are measured. A proximate response is the direct and immediate response of the animal to the stimulus, for example a behavioral (e.g. flight) or a physiological (e.g. change in heart rate) response. This tracks with the first regulatory decision criterion of the Endangered Species Act (ESA), that is, whether the action or activity "may affect" the species. Next, we examine whether the stimulus that elicited the proximate response affects "individual fitness," which is typically evaluated in terms of mortality or reduced nesting success. This is established by field monitoring of many individuals throughout the nesting season. This level of effect tracks with the next decision criterion of the ESA, namely whether the action or activity will "adversely affect" the species. The ultimate level of effect is whether the action or activity causes significant changes in the number of individuals in the population. This level of effect tracks with the final decision criterion of the ESA, which is whether the action or activity is "likely to jeopardize the continued existence" of the species. Population effects will be inferred from measures of individual fitness by application of population viability analysis (PVA) models. Current applications of PVA do not capture the temporal and spatial variability of training events, and thus cannot model the resulting effects on endangered species demographic parameters. USACERL currently is developing PVA modeling approaches capable of capturing training effects in predictive population models. This is a leveraged effort under this project and a related USACERL research effort to evaluate effects of maneuver training (vehicles and troops) on RCWs.

In summary, the research paradigm is that proximate effects can be linked to individual fitness, which in turn can be linked to population effects. As a specific example, consider that a bird might flush from a nest (a proximate response) in response to a noise event. It is possible that this could lead to failure of the nest, especially if it occurred repeatedly. Monitoring is required to determine nesting

success of disturbed and of undisturbed nests. A population model is required to determine if such failure of some percentage of nests has impact on survival of the population.

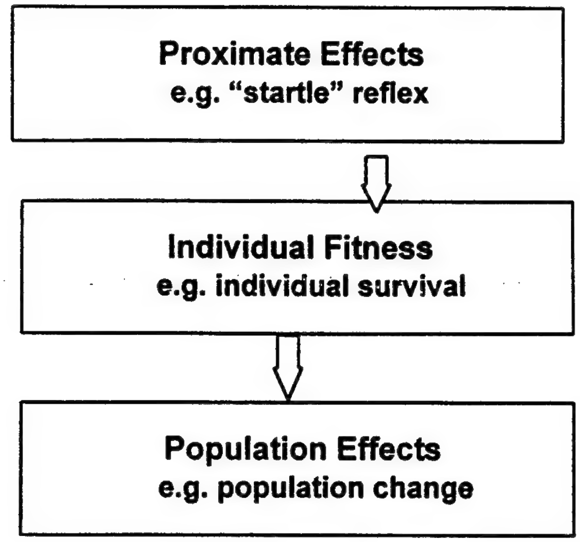

Figure 3. Assessment Hierarchy for Training impact on threatened and endangered species.

Behavior and Proximate Response Measurement Protocols

We documented woodpecker behavior at low and high noise disturbance nest sites by direct observation (camouflaged blinds > 30 m from the nest) and through video surveillance. We divided the nesting cycle into three stages: incubation (eggs present 0-11 days), brooding (small chicks attended by adults: day 12-22), and nestling (larger chicks typically unattended in nest: day 23-until fledging). A "data session" consisted of behavioral observations on at least one adult RCW, typically for a time period of one or more hours. For disturbed sites, we attempted to observe behavior for some period of time before and after the disturbance events, though this was sometimes not possible at passive disturbed sites.

To evaluate RCW baseline behavior and responses to military training activities, we measured several parameters:

(1) alert - RCW moves to the cavity mouth, head movements, orient to noise source;

(2) flush from nest - RCW departs from the nest in response to the stimulus, and remains away from the nest for a measured period of time;

(3) recovery time – length of time an adult is away from the nest after being flushed.

(4) nest attentiveness - proportion of time that the adults spend on the nest through the nesting season (calculated for diurnal, 24-hour periods, and for each nesting phase);

(5) prey deliveries - number and rate of prey deliveries to the nest;

(6) trips - number and duration of times the attending adult left the nest.

RCW behavior categories 3-6 will not be included in this report because these data are not yet fully analyzed.

Demographic and Nesting Success Data

RCW demographic data (population size, growth, density and distribution) were collected in accordance with established protocols used by the Fish and Wildlife Branch DPW on Ft. Stewart. Demographic data included the following parameters for each cluster:

(1) Cluster occupancy - cluster occupied by one or more RCWs. Most individuals are identified by unique leg band combinations. Provides a measure of population size, growth and stability;
(2) Mated status - presence of both an adult male and an adult female RCW;
(3) Active nest - at least one egg was laid;
(4) Nesting success - at least one fledgling was produced. Provides a measure of the proportion of RCW clusters that is reproductively successful;
(5) Nesting productivity – number of young fledged per nest. Provides a measure of fecundity;
(6) Number of eggs produced;
(7) Number of nestlings hatched;
(8) Group size - provides a possible measure of territory quality and availability;

These data enable several trends to be detected:

(1) Reproductive loss - mortality rate of eggs, nestlings and fledglings during nesting;
(2) Nest annual re-occupancy rates - provides a potential measure of RCW response to disturbance. Sites with heavy disturbance levels may be abandoned in subsequent years in favor of other sites further from specific disturbances;
(3) Site tenacity - turnover rate of adult and helper RCWs within a cluster site across years;
(4) nesting success rates at disturbed and undisturbed sites.
(5) mean number of young fledged at disturbed and undisturbed sites;
(6) mean clutch and brood size at disturbed and undisturbed sites;
(7) reproductive potential - total number of young that could be produced if all eggs and nestlings survived to fledge successfully.

Most of the demographic data for Red-cockaded Woodpecker clusters was collected by DPW Fish and Wildlife personnel from Ft. Stewart. Each active (at least one RCW present) cluster was initially visited to determine the cluster occupancy. Adult RCWs were banded by Fish & Wildlife DPW personnel to determine group size and affiliation using methods similar to Walters et al. (1988). A 25% random sample of all RCW clusters were then monitored approximately every 7-9 days to record clutch and brood size. Nestlings were uniquely color banded approximately 5-10 days after hatching. Clusters were visited 20-25 days after nestlings were banded to determine the number and sex of fledglings (Walters et al. 1988). The 25% sample included many of our sample clusters. We augmented the DPW Fish and Wildlife sample by monitoring demographic data (particularly the number of young fledged) for additional cluster sites to provide more complete coverage of our sample clusters.

Video Surveillance

Video cameras are being evaluated as a means to record RCW behavior over prolonged periods, to reduce costs, and to avoid potentially disruptive effects of human presence. The camera systems can also be used to document response in areas that cannot be safely monitored, e.g. downrange of firing positions.

Cameras were attached to tree trunks with adjustable, jointed angle-brackets and screws Cameras were mounted at the same level or slightly above nest height in the nearest practical tree, i.e., large enough to climb to nest height, and at least 5 m from the nest tree so as not to disturb incubating woodpeckers. A power line-and-coaxial-cable down line, covered with camouflaged cloth, was attached to a 10.5-cm, DC monitor and battery so camera placement can be directed from the base of the camera tree. A minimum of two persons is required for camera placement, a climber to position the camera and a person on the ground to check the video signal and placement. To become operational, a trunk line is attached at the base of the tree (covered by a camouflaged 1.2-cm diameter hose for protection against rodents), allowing the power/recording station to be placed 60 m from the tree to minimize potential disturbance to the woodpeckers. We put the recorder, twin batteries, and all connectors inside a weatherproof bin concealed under a camouflaged tarpaulin. Freshly recharged batteries are used for each set of recordings.

We used black and white, charge-coupled device (CCD), video-board cameras to document RCW behavior at 14 nest sites during the 1998 nesting season. The solid state, 12-volt, flexible circuit-board cameras were equipped with 12.0-mm lenses. The cameras provide a minimum of 380 lines of resolution and have a minimum sensitivity of 0.5-Lux. Cameras are mounted in waterproof heavy-gauge plastic switch boxes with transparent covers (12.9 x 6.7 x 4.1 cm) which, except for the lens and LED area, are painted black. Two ports are threaded into the protective housing: one port was for the power supply, while the second port was for the video signal (Delaney et al. 1998).

Panasonic Model AG-1070DC Professional/Industrial VHS video recorders, connected to cameras via coaxial cable (RG-59), provided approximately 24 hours of coverage per tape. These 12-volt, DC powered recorders were designed for field surveillance applications. Cameras and video recorders are powered by two 12-volt, 33.0-amp-hour, Power-Sonic Model PS-12330 sealed rechargeable batteries connected in parallel (a 24-hour taping would draw a single battery below operational limits). These "gel-cell" type batteries (weighing 11.3 kg each) reduce the risk of battery damage, and eliminate the potential for spillage during backpack transport.

Sound Instrumentation and Recording

Sony TCD-D7, Digital Audio Tape (DAT) recorders were used to continuously record all noise events, along with exact time and date. We attached Bruel & Kjaer (B&K) Type 4149 1.3-cm Condenser Microphones with 7.5-cm wind screens to B&K Model 2639 Preamplifiers, mounting the microphone on a 1-m stick, and placing the unit directly under a woodpecker's nest about 1 m from the tree trunk. Two equipment placement procedures were used. In one setup, the B&K Model 2804 Power Supply and DAT recorder were located at our observation point in a camouflaged blind 30 m from the woodpeckers, with three 10 m connecting cables attached to the preamplifier and microphone at the base of the tree. This facilitates tending of the equipment without exposing the human observer during a data session. In an alternate arrangement, the entire package of sound recording equipment was placed at the base of the nest tree in a small camouflaged container. A 1.0 kHz, 94 dB calibration signal (20 micropascals ref.) from a B&K Type 4250 Sound Level Calibrating System was recorded before and after each noise event recording. This signal provides an absolute, standardized reference for sound levels and spectra when data are later analyzed using a B&K Type 2144 Frequency Analyzer. All noise data were analyzed at the U.S. Army Construction Engineering Research Laboratories, Champaign, IL.

In addition to recording noise levels at the base of the nest tree, we also recorded noise levels within nest cavities prior to nesting or at non-nesting sites. These measurements were taken to

estimate how noise levels measured at the ground would need to be adjusted to predict noise levels within the nest cavity.

Sound Metrics

Noise is defined as sound that is undesirable or constitutes an unwarranted disturbance, and can alter behavior or normal functioning (ANSI S1.1-1994). The types of military noise that are within the scope of this study vary widely in instantaneous transient amplitude, duration, spectral energy content, and suddenness of onset. Appropriate noise metrics and frequency weighting are essential to adequately quantify noise impact for each type of noise. Noise metrics are chosen to measure noise dose in a way that meaningfully correlates with subject response. Frequency weighting is an algorithm of frequency-dependent attenuation which simulates the hearing sensitivity and range of the study subjects. Frequency weighting discriminates against sound, which, while easily measured, is not heard by the study subjects. The current project requires specialized metrics and techniques to meaningfully measure noise impacts on animals. Our paradigm is to measure noise events in terms of unweighted one-third-octave-band levels, apply frequency weighting to the resultant spectra, and calculated appropriate overall metrics.

It is well-established (ANSI S12.40-1990, S12.9-1996, S12.17-1996, Homans 1974, NAS 1977, 1981, Rice 1983, 1986, Schomer 1986, 1994) that the appropriate metric for blast noise is sound exposure level (SEL), which is essentially the time integral of the square of the acoustic pressure. We measured blast noise as unweighted 1/3-octave band sound exposure levels (SEL), to which frequency weighting appropriate for the RCW will be applied (when available from the audiogram portion of this study, described in Appendix A) to obtain appropriately-weighted overall levels. The same metric and procedure was also used with small arms noise (Buchta 1990, Hede 1982, Hoffman 1985, Luz 1982, Sorenson 1979, Vos 1995). Two metrics, the SEL and the maximum 1-second equivalent average (LEQ) level, were used for helicopter noise, airplane noise and vehicle pass-by noise, since both are meaningful in terms of correlation with response (EPA 1974, 1982, FICUN 1980, Fidell 1991, Schomer 1994, Schultz 1978, USCFR 1980). Ambient noise was measured as LEQ for various appropriate time periods (EPA 1982). In all cases, the noise signals were recorded on digital audio tapes and preserved for possible further analysis.

Only noise that is audible to the study species should be accounted for in the metric used to quantify noise level. The commonly used "A" frequency weighting (ANSI S1.4-1983) attenuates noise energy according to human hearing range and sensitivity. For human response to blast noise, "C" frequency weighting is often applied to received blast noise signals, rather than "A" weighting which is more representative of human hearing response (ANSI S1.4-1983). This is done to retain low frequency energy that, while not heard by humans, causes a secondary rattle in buildings which does evoke response (ANSI S12.4-1986). This is not appropriate for wildlife. Frequency weighting designed for humans will in general not be appropriate for animal species. An audiogram, which describes hearing range and sensitivity, provides guidance regarding appropriate frequency weighting for the species of interest and also aids in interpretation of noise response data. Figure 4 shows a composite average audiogram of seven orders of birds, with an approximate representation of a human audiogram and the "A" weighting curve included for comparison. The differences are substantial. The "owl" audiogram further illustrates how audiograms can vary among species. We searched the literature and consulted several leading experts on bird hearing without finding an audiogram for the RCW or for any species in RCW's order, *Piciformes*. Thus as part of this project we will obtain an

audiogram that will be used to develop a frequency weighting function that is appropriate for woodpeckers. A report on the status of this effort is included as Appendix A.

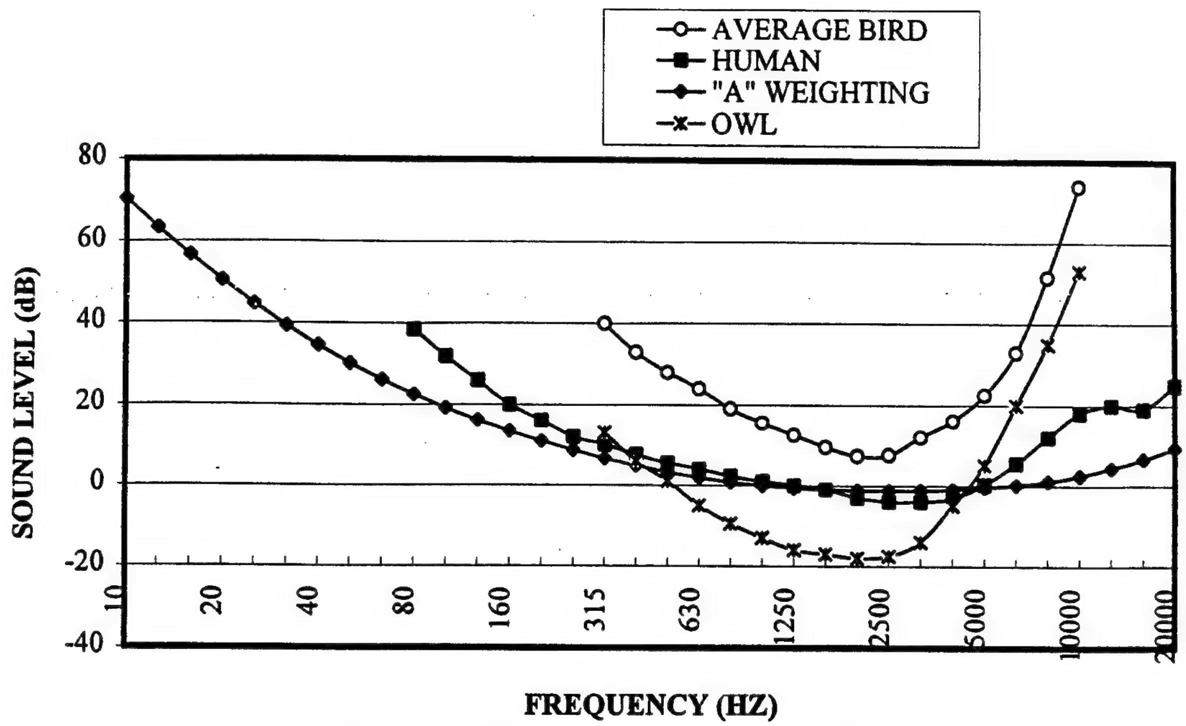

Figure 4. Examples of Audiograms and Frequency Weighting

Statistical Data Analysis

We used SPSS 8.0 for Windows (SPSS Inc. 1998) to perform all descriptive statistics, for example, independent-sample *t*-tests for comparing the mean number of eggs, nestlings, and young fledged between 1st and 2nd nesting attempts. Whenever appropriate, multiple observations at single nests were averaged before inferential tests were performed so that the sample sizes are the number of nests examined. We used a one-tailed Fisher Exact Test to assess 2x2 contingency tables for variability in nesting success between disturbed and undisturbed nest sites (Zar 1984). Alpha levels of 0.05 and power 0.80 will be required to reject a null hypothesis for all tests. Means ± standard error (SE) are presented in the text.

RESULTS

Initiation Dates for each Nesting Phase

The first woodpecker clutches were initiated on approximately 17 April through 10 May, while secondary clutches (clusters that re-nested after initial nest failure) were initiated from 12 May through 12 June. Eggs from initial nesting attempts hatched from approximately 27 April through 20 May, while nests from 2nd nesting attempts hatched from 22 May through 21 June. We observed young fledging from initial nesting attempts from 23 May through 14 June, and from 16 June through 16 July for secondary nesting attempts.

Overall Population Dynamics

Of the 165 potential breeding pairs on Ft. Stewart, 141 nested during the 1998 nesting season (85.5%). Of the clusters that nested for which we have good data (114 clusters), 87.7% fledged young successfully. Sixteen of the 25 clusters that initially failed to nest were found re-nesting within the following two weeks, with 75% of these sites successfully fledging young. Clusters that re-nested were found to be as successful (Fisher Exact Test, $P > 0.05$; 75% for sites that re-nested versus 89.8% for initial nesting attempts) and productive as sites that nested only once. We observed no statistically significant difference in number of eggs ($F_{1,130} = 0.12$, $P = 0.74$), nestlings ($F_{1,131} = 0.12$, $P = 0.74$), or the number of young fledged ($F_{1,100} = 2.32$, $P = 0.13$) between sites that re-nested and those that nested only once. We then pooled these data to determine mean rates for the overall population. Mean clutch size for RCW nests was 3.01 ± 0.08 eggs/nest, mean brood size was 2.09 ± 0.07 nestlings/nest, and the number of young fledged was 1.75 ± 0.09 young/occupied nest (1.99 ± 0.07 young/successful nest). Occupied nests include sites that are successful as well as sites that are not. Successful nests only include those sites that are successful in fledging young. Just over half of the young that fledged were male (53.3%). There was a 38.7% decline in the reproductive potential of RCW nests from the incubation phase to the nestling phase ($F_{1,229} = 99.47$, $P < 0.001$). The decline was not as dramatic from the nestling phase to the fledgling phase (10.3%), but was still significant ($F_{1,205} = 4.12$, $P = 0.04$). Overall, we observed a significant decline of 45.7% in the reproductive potential from incubation through the fledgling phase ($F_{1,225} = 136.49$, $P < 0.001$).

Sample Cluster Population Dynamics

Disturbed and undisturbed nest sites did not differ significantly in the number of eggs ($F_{1,48} = 0.00$, $P = 0.99$), number of nestlings ($F_{1,40} = 1.27$, $P = 0.27$), or number of young fledged ($F_{1,39} = 0.04$, $P = 0.84$). Twenty-one of the 25 disturbed RCW nest sites were successful in producing an average of 1.68 ± 0.20 young/occupied nest (2.00 ± 0.15 young/ successful nest), while 13 of 16 undisturbed sites were successful in producing an average of 1.75 ± 0.28 young/occupied nest (2.15 ± 0.22 young/ successful nest). For disturbed sites, seven of the 25 nesting attempts were second attempts. For undisturbed sites, zero of 16 nesting attempts were second attempts. This difference was not statistically significant (Fisher Exact Test, $P > 0.05$). As was the case for the population as a whole, sites that re-nested after initial nesting failure were as successful and productive as sites that nested only once. Therefore, data were pooled before determining overall sample group fitness rates. These results should be viewed as preliminary, since the sample sizes and thus the statistical power were limited.

Of the 14 clusters that failed to produce young during 1998, we only were able to confirm one case of nest predation (video site; rat snake, *Elaphe obsoleta*). Two other sites may have failed due to

nest predation (rat snake and flying squirrel [*Glaucomys volans*] were present in the nest cavity during nest checks), but we could not confirm that these sites were still active just prior to occupation by these animals. We also documented (video site) one case of an attempted nest predation of an RCW nest by a hawk.

Noise and Response Monitoring Summary

During the 1998 field season we documented RCW response to passive noise from large caliber live fire (25 mm M2A2 Bradley Fighting Vehicles, 120 mm M1A1-Tanks, and 155 mm M109 Holwitzers), small arms live fire (5.56 mm M-16 and Saw, 7.62 mm, 9 mm, and .50 caliber machine guns), military helicopters, fixed-wing aircraft, military vehicles, artillery simulators, and Multiple Launch Rocket Systems (MLRS) as they occurred. During experimental testing we presented woodpeckers with controlled small arms blank fire noise. Passive noise was monitored during all nesting phases, while blank fire tests were only performed during the incubation and early portions of the brooding phase when adults were present at the nest for extended periods of time.

We made noise measurements and behavioral response observations at a total of 34 disturbed (passive or experimental) sample clusters. Detailed results are described below and are presented in the data tables and figures in Appendices B, C and E. The tables of Appendix B present summaries of the noise level measurements and RCW responses. Appendix E presents noise level summaries for each noise stimulus type as well as detailed noise measurements in terms of one-third-octave-band SEL levels. These are the data to which future adjustments for cavity resonance and woodpecker frequency weighting will be applied to obtain single-number overall noise levels. A typical spectrum for each type of noise is presented in Appendix C. We also made behavioral observations at a total of 16 undisturbed sample clusters for the purpose of obtaining baseline against which to judge proximate response at the disturbed clusters.

Our original intent was to observe each disturbed cluster at least once during both the incubation and nestling phases of nesting. However, this was sometimes not possible because ranges did not fire as scheduled or military activities were canceled. Therefore, some clusters were visited more than once and others were not observed at all.

Passive Monitoring - We recorded 1,041 passive noise events in 56 data sessions at 34 RCW clusters during the 1998 nesting season. Large caliber live fire events (> 20 mm in diameter) were recorded most frequency, followed by small arms live fire (.50 caliber and below), vehicle maneuver noise, fixed-wing aircraft, helicopters, artillery simulators, and Multiple Launch Rocket System fire (MLRS). Multiple noise events and stimulus types were usually recorded during each data session. Most stimulus events were distant and had relatively low noise levels, as shown in the tables of Appendix B. Over 60% of all data sessions were recorded during the nestling phase (Appendix E).

Experimental Testing – We exposed RCWs to small arms blank fire (5.56 mm M-16) fired at a distance of 15.2 m from the nest tree during a 5 min period. Due to various logistical constraints, only four tests were conducted at RCW nest sites during 1998 (clusters 36, 37, 76, and 142; Appendix B, Table B8).

Noise Measurement Test - In addition to recording noise levels at the base of active RCW nest sites, we also measured noise levels in RCW nest cavities and at the base of the tree, for comparison. The measurements were performed prior to nesting or at non-nesting sites; only artificial cavities were tested in 1998. Artificial nest cavities were found to act as sound resonators, emphasizing the 250 Hz one-third-octave frequency band. In the example presented in Figure 5, artillery muzzle blast noise

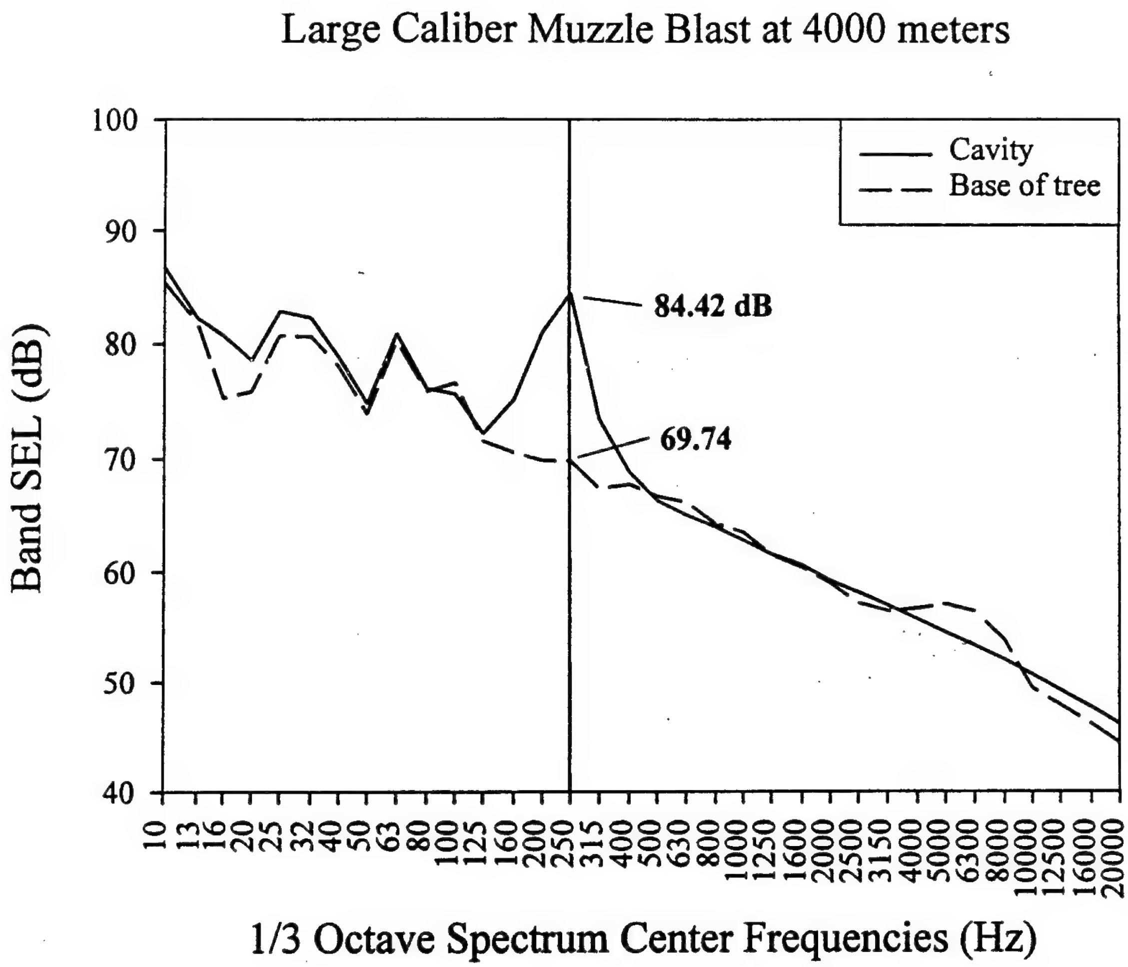

Figure 5. Example comparison of band SEL levels for noise recordings at the base of nest trees versus recordings inside nest cavities (cluster 199, 5 June 1998).

was 14.7 dB louder within the cavity at the 250 Hz frequency range than noise recorded for the same blast event at the base of the nest tree. This has important consequences for any future extrapolation of noise levels from measurements we record at the base of nest trees versus what RCWs may actually be experiencing within nest cavities. We will investigate this in more detail in FY99. We also plan to test for any differences between artificial and natural cavities during the 1999 field season.

RCW Flush Response

Three possible flush responses were observed at RCW nest sites during the 1998 breeding season (2 at cluster 83 and 1 at cluster 142). Each flush response is examined here in detail. Both of the flush responses at cluster 83 occurred during close artillery blast noise. This site received the highest noise levels of any RCW cluster site monitored. On 20 May 1998, we recorded 13 blast events during a data session at cluster 83. In Figure 6, blasts 1-8 are shown in terms of both unweighted and A-weighted SEL for each blast. The attending adult appeared to flush during the

loudest blast event recorded during that data session (7th of 13 blast events recorded, SEL = 87.7 dBA). The RCW returned to the nest after 6.25 min and did not flush again in response to several subsequent blasts. On 21 May 1998, we recorded 60 blast events during another data session at cluster 83. This time the attending adult appeared to flush in response to the 52nd blast event during that data session, returning to the nest after 4.42 min, as shown in Figure 7. This blast event was one of the louder blasts of the day, but not the loudest (90.9 dBA). The RCW returned to the nest after 4.42 min., shortly before the last noise event occurred.

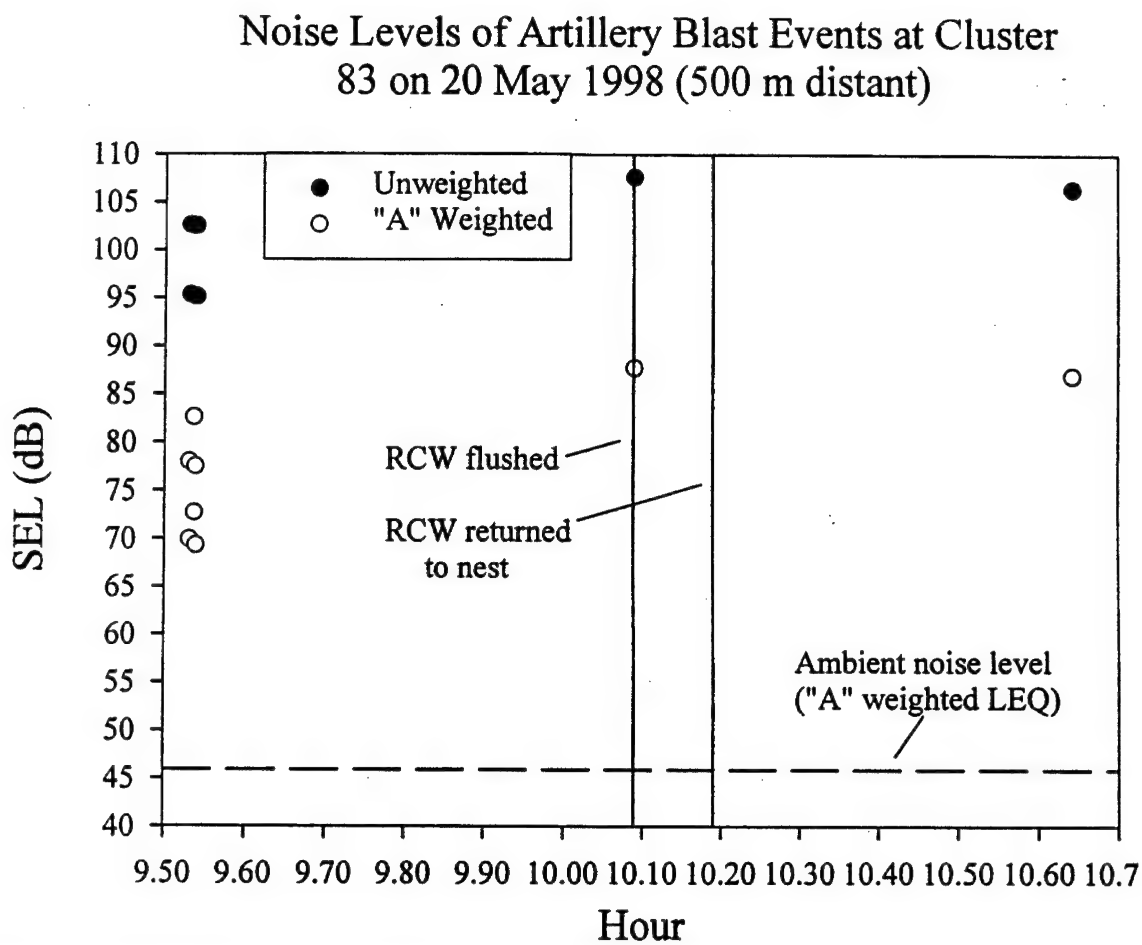

Figure 6. Description of RCW flush response to artillery blast events at cluster 83 on 20 May 1998 on Ft. Stewart, GA. Attending RCW flushed in response to loudest blast event of the day. An adult RCW returned to the nest to continue incubating after 6.25 min, before subsequent noise events.

The 3rd flush event occurred during an experimental blank fire test at cluster 142. An RCW adult appeared to flush from the nest 2 sec after experimental M-16 blank firing began, with an RCW returning to the nest 10 sec after firing ended (Figure 7; total elapsed time off the nest: 5.06 min). Only one of four experimental blank fire tests elicited a flush response. M-16 blank fire testing will be expanded during the 1999 field season to include a larger sample size to develop a distance and noise response threshold for RCWs.

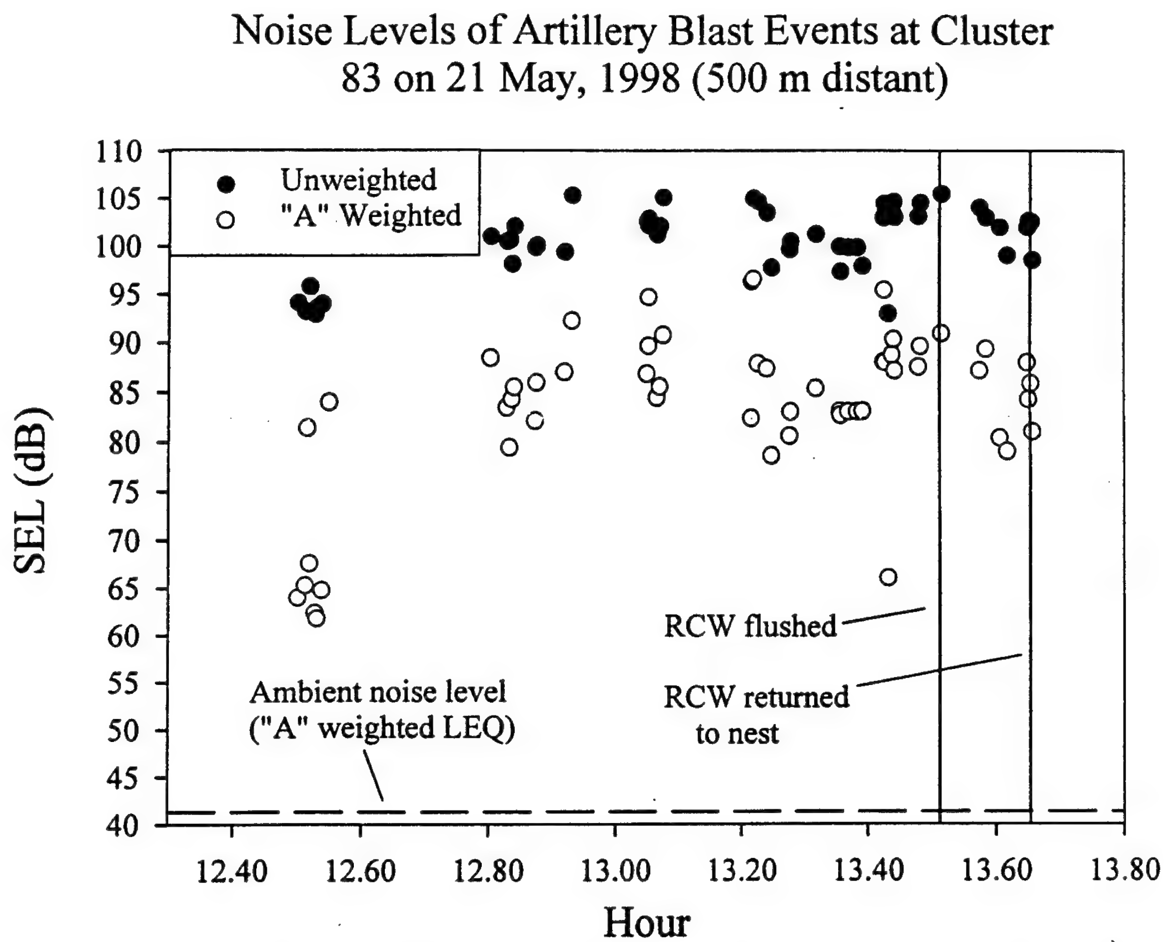

Figure 7. Description of RCW flush response to artillery blast events at cluster 83 on 21 May 1998 on Ft. Stewart, GA. Attending RCW flushed in response to loudest blast event of the day. An adult RCW returned to the nest to continue incubating after 4.42 min, before the final noise event.

Distance and Noise Level Thresholds for Response

Large Caliber Live Fire – The 1998 field season data show that RCWs did not flush when large caliber guns were fired at distances > 1800 m from nest sites (accounting for 88% of all large caliber blasts recorded) and SEL noise levels were < 87 dBA (105 dB, unweighted; Appendix B, Table B1). We only monitored RCW response to blast noise at a distance of < 1800 m at one active nest site (~ 500 m, cluster 83, ~12% of all blasts events recorded). We did not locate any active nests between 500-1800 m of blast sites, therefore, we could not test for response within that range.

Small Caliber Live Fire - RCWs did not flush when small arms live fire was > 1000 m from nest sites and SEL noise levels were < 63 dBA (76 dB, unweighted; Appendix B, Table B2). We did not locate any active RCW nest sites within 800 of any small arms ranges to which we had access for testing purposes.

Helicopters - RCWs did not flush when military helicopters were > 60 m from nest sites and SEL noise levels were < 85 dBA (102 dB, unweighted; Appendix B, Table B3). Due to the low probability of encountering helicopters, we were unable to test for RCW response at distances < 60 m.

Military Vehicles - RCWs did not flush when military vehicle traffic was > 60 m from nests and SEL noise levels were < 92 dBA (106 dB, unweighted; Appendix B, Table B4).

Artillery Simulators - RCWs did not flush when artillery simulators were > 1600 m from nest sites and SEL noise levels were < 72 dBA (82 dB, unweighted; Appendix B, Table B5). We did not encounter any artillery simulators < 1600 m from active RCW nest sites.

MLRS - RCWs did not flush when rockets were launched > 2400 m from nest sites and SEL noise levels were < 59 dBA (82 dB, unweighted; Appendix B, Table B6).

Fixed-wing Aircraft – RCWs did not flush when airplanes were > 1000 m from nest sites and SEL noise levels were < 87 dBA (94 dB, unweighted; Appendix B, Table B7).

Blank Fire Testing - We did not vary stimulus distance during blank fire testing and therefore were not able to develop a preliminary distance or sound threshold (Appendix B, Table B8).

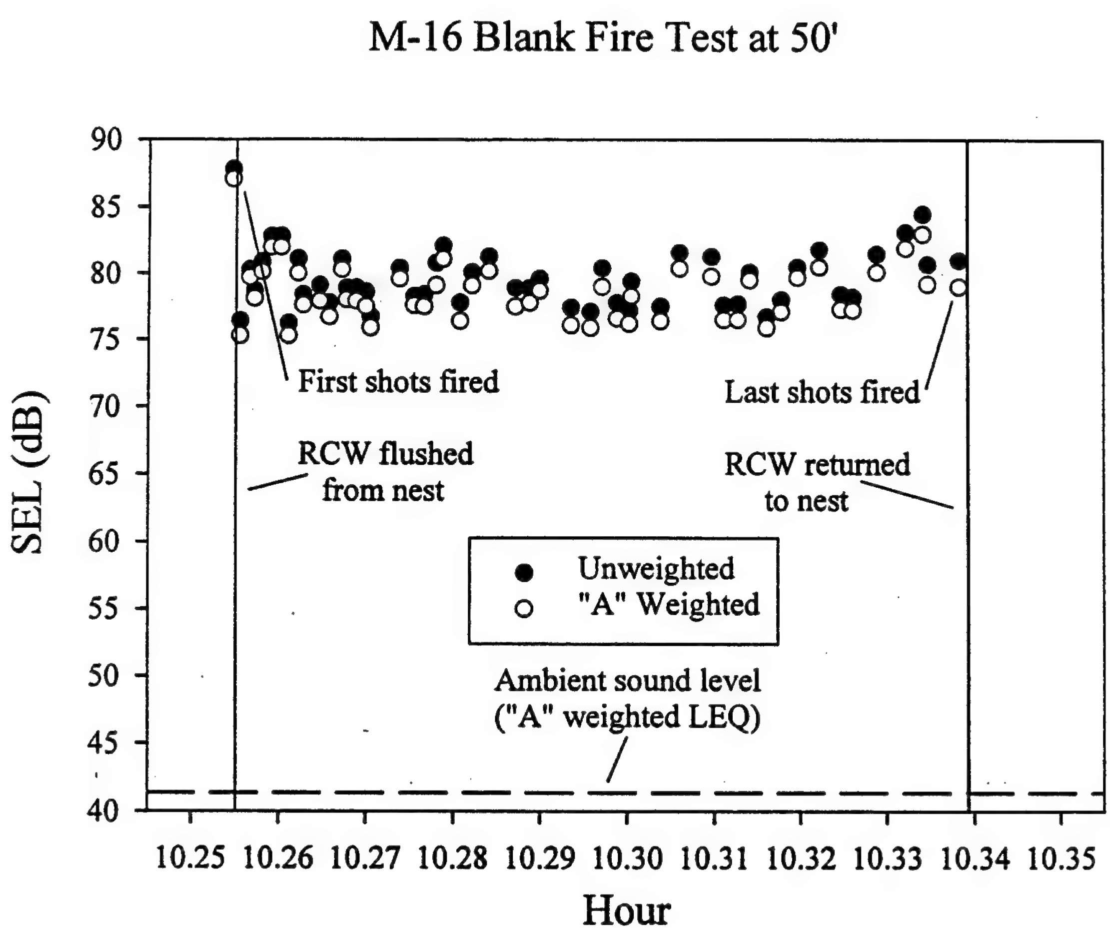

Figure 8. Description of RCW flush response to small arms blank fire at cluster 142 on 3 June 1998 on Ft. Stewart, GA. Attending RCW flushed in response to 1st series of muzzle blasts. An adult RCW returned to the nest to continue incubating after 5.06 min.

DISCUSSION

Nesting Success

Our preliminary data, based on the military training intensity and noise levels recorded during this 1st year of study, suggest that measured levels of military training noise did not impact RCW nesting success or productivity. It is of course possible that under more intensive circumstances, for example increased training intensity and noise levels, that RCW nesting success might be impacted. Small sample size and low sample power restrict our ability to make any strong conclusions based on this year's data. Through further investigation over the next two years we will be able to make more definitive conclusions regarding RCW fitness as a function of training noise.

Flush Response

Red-cockaded Woodpeckers flushed infrequently in response to military training noise during the 1998 nesting season. Most of the passive noise events that we recorded were distant and had relatively low noise levels. It is possible that RCWs have shifted their location on the landscape to lessen the effect of military training noise. This could explain why there seem to be few active nest sites in close proximity to heavily used large caliber live fire ranges and the Artillery Impact Area on Ft. Stewart. RCWs have been shown to shift their home range due to military activity (Jackson and Parris 1995). Shifts in home range use have also been noted in response to military training for other bird species as well (Anderson et al. 1990).

Woodpeckers quickly returned to their nests after being flushed. Recovery times by RCWs were comparable with times reported for birds species in other noise disturbance studies (Awbrey and Bowles 1990, Holthuijzen et al. 1990). The amount of time that an attending adult is away from the nest has important consequences when we consider the role that nest predation and nest competition has on this species. There are a number of species that are capable of usurping nesting cavities from the RCW. Both red-bellied (*Melanerpes carolinus*) and red-headed woodpeckers (*Melanerpes erythrocephalus*) have been shown to remove and eat eggs, usually in the process of usurping the cavity from the RCW. Southern flying squirrels (*Glaucomys volans*) have also been documented to eat eggs or young when competing with RCWs for nest cavities (Jackson 1994).

Distance and Sound Thresholds

An examination of the data presented in Appendices B and E reveals a wide range of received noise levels at a given distance. One reason is that different types of noise sources of course have different acoustic emissive power. For a given noise source, the most important reason is differences in propagation conditions, a result of differences in atmospheric wind and temperature structure. It is well-known that, at distances of several kilometers, received noise level can vary by as much as 20 dB above and below the mean due to changes in meteorological conditions (Embleton 1982, Li 1994, Larsson 1991, Pater 1981, Piercy 1977, White 1989, 1993). Differences in received noise level can also be due to orientation of the weapon relative to the receiver. Many weapons exhibit substantial directivity, some as much as 15 dB louder downrange (Pater 1981, 1999, Schomer 1976, 1979, 1981, 1982, 1984, 1985, 1986, Walther 1972).

PLANS

The results of the first year of the project have shown that our basic technical approach is appropriate and effective. The primary need is for more data. We plan to increase the number of personnel engaged in gathering field data during the 1999 nesting season. We will in particular obtain more data for small arms blanks and for helicopters, and possibly do experimental manipulations using artillery simulators. We will search for reproductively active clusters located so as to fill in the blanks in our data in terms of stimulus distance and noise level.

The matter of cavity resonance effect on the noise level perceived by the RCWs will be investigated. We cannot measure noise levels in the cavity of an endangered species during the nesting season. Thus we will need to develop an algorithm for extrapolating from noise levels measured at the base of the tree.

The investigation of woodpecker hearing is beginning to return useful results; the current effort will be continued. An expanded effort may be appropriate.

The use of cameras for untended monitoring of activity has proven to be useful. The camera systems will be improved and will be selectively used, since viewing of the tapes, even at a substantial time compression, is extremely time consuming.

One aspect of our technical approach that has not yet been executed is to use available noise models and training activity data to calculate noise dose for each cluster, and to examine these data for correlation with nesting success data. Ft. Stewart installed the updated version of the RFMSS system early in 1998, which includes detailed data regarding training activity. These data will be used in 1999 to examine said correlation.

CONCLUSION

During the first year of our study of the impacts of training noise on the RCW, we observed and documented training noise events and the resulting RCW responses under realistic conditions. We measured both proximate response behavior and nesting success. We also observed RCW behavior and nesting success at clusters where noise stimuli were absent or minimal (near or below ambient sound levels), to provide an undisturbed behavior baseline against which to judge response and impact. Very few candidate proximate responses to noise occurred. No significant difference in nesting success was found between disturbed and relatively undisturbed nest sites. The first year data are limited in number and statistical power and are not sufficient to make strong conclusions or to establish reliable noise dose-response relations or thresholds. The results are however sufficient to confirm that the project technical approach is appropriate and needs only minor revision, and that the project objectives will be achieved.

REFERENCES

Biology

Anderson, D. E., O. J. Rongstad, and W. R. Mytton. 1989. Response of nesting red-tailed hawks to helicopter flights. Condor 91:296-299.

Awbrey, F. T., and A. E. Bowles. 1990. The effects of aircraft noise and sonic booms on raptors: a preliminary model and a synthesis of the literature on disturbance. Noise and Sonic Boom Impact Technology, Technical Operating Report 12. Wright-Patterson Air Force Base, Ohio, USA.

Beaty, T. A. 1986. Response of Red-cockaded Woodpeckers to habitat alteration. Directorate of Engineering and Housing, Fish and Wildlife Section, Ft. Stewart, GA. 20 pp.

Bowles, A. E. 1995. Responses of wildlife to noise. Pages 109-156 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife Recreationists, Island Press, Washington, D.C. USA.

Bowles, A. E., F. T. Awbrey, and R. Kull. 1990. A model for the effects of aircraft overflight noise on the reproductive success of raptorial birds. Noise and Sonic Boom Impact Technology, Inter-Noise 90. Wright-Patterson Air Force Base, Ohio, USA.

Carrier, W. D. and W. E. Melquist. 1976. The use of a rotor-winged aircraft in conducting nesting surveys of ospreys in northern Idaho. J. Raptor Res. 10:77-83.

Charbonneau, D., L. Swindell, E. J. Moore, T. A. Beaty, and A. Eaton. 1983. Preliminary report o the effects of forage habitat reduction on Red-cockaded Woodpecker reproduction in the CALFAX Range Facility at Ft. Stewart, Georgia. Directorate of Engineering and Housing, Fish and Wildlife Section, Ft. Stewart, GA. 53 pp.

Costa, R. 1992. Challenges for recovery. Pages 37-44 in Proceedings from Sandhills Red-cockaded Woodpecker conference. D. J. Case and Assoc., Mishawaka, Inc.

Craig, T.H., and E.H. Craig. 1984. Results of a helicopter survey of cliff nesting raptors in a deep canyon in southern Idaho. Journal of Raptor Research 18:20-25.

Delaney, D. K., T. G. Grubb, P. Beier, L. L. Pater, and M. H. Reiser. 1999. Effects of helicopter noise on Mexican Spotted Owls. J. Wildl. Manage. 63:60-76.

Delaney, D. K., T. G. Grubb, and D. K. Garcelon. 1998. An infrared video camera system for monitoring diurnal and nocturnal raptors. J. Raptor. Res. 33:290-296

Delaney, D. K., T. G. Grubb, and L. L. Pater. 1997. Effects of helicopter noise on nesting Mexican Spotted Owls. Project Order No. CE P.O. 95-4. Rep. USAF 49 CES/CEV, Holloman Air Force Base, NM.

Devlin, W. J., J. A. Mosher, and G. J. Taylor. 1980. History and present status of the Red-cockaded Woodpecker in Maryland. Am. Birds 34:314-316.

Edwards, R. G., A.B. Broderson, R. W. Barbour, D. F. McCoy, and C. W. Johnson. 1979. Assessment of the environmental compatibility of differing helicopter noise certification standards. Final Report for the Department of Transportation, WA. Report #FAA-AEE-19-13. Contract #784190000000000.

Ellis, D. H. 1981. Responses of raptorial birds to low level military jets and sonic booms: Results of the 1980--81 Joint U.S. Air Force-U.S. Fish and Wildlife Service Study. Institute for Raptor Studies Report NTIS ADA108-778.

Ellis, D. H., C. H. Ellis, and D. P. Mindell. 1991. Raptor responses to low-level jet aircraft and sonic booms. Environmental Pollution 74:53-83.

Fort Stewart Endangered Species Management Planning Team. 1998. Endangered species management plan. 116 pages.

Fraser, J. D., L. D. Frenzel, and J. E. Mathisen. 1985. The impact of human activities on breeding bald eagles in north-central Minnesota. Journal of Wildlife Management 49:585-592.

Fyfe, R. W., and R. R. Olendorff. 1976. Minimizing the dangers of studies to raptors and other sensitive species. Canadian Wildlife Service Occasional Paper 23.

Grubb, T. G., and W. W. Bowerman. 1997. Variations in breeding bald eagle response to jets, light planes, and helicopters. Journal of Raptor Research 31:213-222.

Grubb, T. G., W. W. Bowerman, J. P. Giesy, and G. A. Dawson. 1992. Responses of breeding bald eagles, *Haliaeetus leucocephalus*, to human activities in north-central Michigan. Canadian Field-Naturalist 106:443-453.

Grubb, T. G. and R. M. King. 1991. Assessing human disturbance of breeding bald eagles with classification tree models. Journal of Wildlife Management 55:501-512.

Hayden, T. J. 1997. Biological assessment of the effects of the proposed revision of the 1994 management guidelines for the Red-cockaded Woodpecker on Army installations. USACERL Special Report 97/48. 101 pages.

Hohman, W. L. 1986. Incubation rhythms of Ring-necked Ducks. Condor 88:290-296.

Holling, E. D. 1991. The environment can ground training. Naval Proceedings, October 1991: 71-75.

Holthuijzen, A. M. A., W. G. Eastland, A. R. Ansell, M. N. Kochert, R. D. Williams, and L. S. Young. 1990. Effects of blasting on behavior and productivity of nesting prairie falcons. Wildlife Society Bulletin 18:270-281.

Jackson, J. A. 1994. Red-cockaded woodpecker (Picoides borealis). Pp. 1-19 *in* A. Poole and F. Gill, eds. The birds of North America, No. 85. The Academy of Natural Sciences, Washington, D. C. The American Ornithologists Union.

Jackson, J. A. 1987. The Red-cockaded Woodpecker. Pp. 479-493 *in* R. L. DiSilvestro, ed. Audubon wildlife report 1987 Academic Press, New York.

Jackson, J. A. 1983. Possible effects of excessive noise on post-fledging Red-cockaded Woodpeckers. Pp. 38-40 in Red-cockaded Woodpecker symposium II proceedings (D. A. Wood, ed.). Fla. Game Fresh Water Fish Commission, Tallahassee, FL.

Jackson, J.A. 1978. Analysis of the distribution and population status of the Red-cockaded Woodpecker. Pp. 101-111 *in* R. R. Odum and L. Landers, eds. Proceedings of the rare and endangered wildlife symposium. Georgia Dep. Nat. Res., Game Fish Div., Tech. Bull. WL 4.

Jackson, J. A. and S. D. Parris. 1995. The ecology of Red-cockaded Woodpeckers associated with construction and use of a multi-purpose range complex at Ft. Polk, Louisiana. Pages 277-282 *in* D. L. Kulhavy, R. G. Hooper, and R. Costa, eds. Red cockaded Woodpecker: recovery, ecology, and management. Center for Applied Studies in Forestry, College of Forestry, Stephen F. Austin State University, Nacogdoches, TX.

Jordan, R. A., K. S. Wheaton, W. M. Weiher, and T. J. Hayden. Integrated endangered species management recommendations for Army Installations in the Southeastern United States. USACERL Special Report 97/94. 168 pp.

Jordan, R. A., K. S. Weaton, and W. M. Weiher. 1995. Integrated endangered species management recommendations for Army Installations in the Southeastern United States: Assessment of the potential effects of Army-wide management guidelines for the Red-cockaded Woodpecker on associated endangered, threatened, and candidate species. Final Report, The Nature Conservancy Southeast Regional Office, North Carolina. 132 pp.

Knight, R. L., and S. A. Temple. 1986. Why does intensity of avian nest defense increase during the nesting cycle? Auk 103:318-327.

Lawrence, G. N. 1867. "Catalogue of birds observed in New York, Long and Staten Islands and the adjacent parts of New Jersey", Annual Lyceum of the Natural History of New York 8:279-300.

Lennartz, M. R., P. H. Geissler, R. F. Harlow, R. C. Long, K. M. Chitwood, and J. A. Jackson. 1983. Status of the Red-cockaded Woodpecker on federal lands in the south. Pp. 7-12 *in* D. A. Wood, ed. Red-cockaded Woodpecker symposium II Proceedings. Fla. Game Fresh Water Fish Commission, Tallahassee, Fl.

McGarigal, K., R. G. Anthony, and F. B. Isaacs. 1991. Interactions of humans and bald eagles on the Columbia River estuary. Wildlife Monograph 115:1-47.

Platt, J. B. 1977. The breeding behavior of wild and captive gyrfalcons in relation to their environment and human disturbance. Ph.D. dissertation . Cornell University, Ithaca, New York, USA.

Scott, J. M., S. A. Temple, D. L. Harlow, and M. L. Shaffer. 1994. Restoration and management of endangered species. Pages 531-539 *in* T. A. Bookhout, ed. Research and management techniques for wildlife and habitats. Fifth ed. The Wildlife Society, Bethesda, MD.

Snyer, N.F.R., H.W. Kale II, and P.W. Sykes, Jr. 1978. An evaluation of some potential impacts of the proposed Dade County training jetport on the endangered Everglade Kite. FWS, Patuxent Wildl. Res. Cent., Maryland.

SPSS, Inc. 1998. SPSS 8.0 for Windows: base, professional statistics, and advanced statistics. SPSS, Inc., Chicago, IL

Stalmaster, M. V., and J. L. Kaiser. 1997. Flushing responses of wintering bald eagles to military activity. Journal of Wildlife Management 61:1307-1313.

Steenhof, K. and M. N. Kochert. 1982. An evaluation of methods used to estimate raptor nesting success. J. Wildl. Manage. 46:885-893.

Tazik, D. J., J. D. Cornelius, D. M. Herbert, T. J. Hayden, and B. R. Jones. 1992. Biological assessment of the effects of military associated activities on endangered species at Fort Hood, Texas. USACERL Special Report EN-93/01.

Thiessen, G. 1957. Acoustic irritation threshold of ring-billed gulls. Journal of Acoustical Society of America 29:1307-1309.

The Nature Conservancy. 1996. Effects of military training on the Red-cockaded Woodpecker. Final Report for Fort Benning Army Installation.

Windsor, J. 1977. The response of Peregrine Falcons (*Falco peregrinus*) to aircraft and human disturbance. Mackenzie Valley Pipeline Investigations, Report for Environmental Social Programs. Canadian Wildl. Serv. 87 pp.

Zar, J. H. 1984. Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, New Jersey.

Noise

ANSI, American National Standards Institute S1.1-1994, "American National Standard: Acoustical Terminology," 1994.

ANSI, American National Standards Institute S1.4-1983, "American National Standard Specification for Sound Level Meters," 1983.

ANSI, American National Standards Institute S12.17-1996, "Impulse Sound Propagation for Environmental Noise Assessment," August 1996.

ANSI, American National Standards Institute S12.4-1986, "American National Standard Method for Assessment of High-Energy Impulsive Sounds with Respect to Residential Communities," 1986.

ANSI, American National Standards Institute S12.40-1990, "Sound Level Descriptors for Determination of Compatible Land Use," 1990.

ANSI, American National Standards Institute S12.9-1996, "Quantities and Procedures for Description and Measurement of Environmental Sound – Part 4: Noise Assessment and Prediction of Long-term Community Response," September 1996.

Buchta, E., "A field survey of annoyance caused by sounds from small firearms," J. Acoust. Soc. Am., 88, 1459-1467, 1990.

DeJong and Commins, "CEC Joint Research on Annoyance due to Impulse Noise: Field Studies," Noise as a Public Health Problem: Proceedings of the Fourth International Congress, Volume 2, G. Rossi, Editor, Cetnro Ricerche E Studi Amplifon, Milan, Italy, 1085-1093, 1983.

Embleton, T., "Sound Propagation Outdoors – Improved Prediction Schemes for the 80"s," Noise Control Engineering Journal, 18/1, 30-39, 1982.

EPA, "Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety," U.S. Environmental Protection Agency, Report No. 550/9-74-004, March 1974.

EPA, "Guidelines for Noise Impact Analysis," U.S. Environmental Protection Agency, Report No. 550/9-891-105, April 1982.

FICUN, Federal Interagency Committee on Urban Noise, "Guidelines for Considering Noise in Land Use Planning and Control," 1980.

Fidell, S. et. al., "Revision of a Dosage Effect Relationship for the Prevalence of Annoyance Due to General Transportation Noise," J. Acoust. Soc. Am., 89, 221-233, 1991.

Hede and Bullen, "Community reaction to noise from a suburban rifle range," Journal of Sound and Vibration, 82, 39-49, 1982.

Hoffman, R., A. Rosenheck, and U. Guggenbuehl, "Assessment Procedure for Rifle Firing Noise from 300 Meter Facilities," EMPA Department for Acoustics and Noise Abatement, Swiss Federal Office for Environmental Protection, February 1985.

Homans, B., "User Manual for the Acquisition and Evaluation of Operational Blast Noise Data," USACERL Technical Report E-42, June 1974.

Li, Y.L., M. J. White and S.J. Franke, "New fast field programs for anisotropic sound propagation through a wind velocity profile," J. Acoust. Soc. Am. 95, 718-726, February 1994.

Larsson, C. and S. Israelsson, "Effects of Meteorological Conditions and Source Height on Sound Propagation near the Ground," Applied Acoustics 33 (1991), 109-121, 1991.

Luz, G., "An improved procedure for evaluating the annoyance of small arms ranges," J. Acoust. Soc. Am., 72, Suppl. 1, S26, 1982.

Maekawa, Z., "Noise Reduction by Screens," Applied Acoustics, 1, 157-173, 1968.

McBryan, J., "Compilation of Operational Blast Noise Data," USACERL Technical Report N-82, January 1980.

NAS, National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics, Working Group 84 Report, "Assessment of Community Response to High-Energy Impulsive Sounds," 1981.

NAS, National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics, Working Group 69 Report, "Guidelines for Preparing Environmental Impact Statements on Noise," 1977.

Ogura, Y., Y. Suzuki and T. Sone, "A new method for loudness evaluation of noises with impulsive components," Noise Control Engineering Journal, 40, 231-240, 1993.

Pater, L., "Noise Abatement Program for Explosive Operations at NSWC/DL," 17th Explosives Safety Seminar of the Department of Defense Explosives Safety Board, 1976.

Pater, L., "Gun Blast Far Field Overpressure Contours," Naval Surface Weapons Center, TR-79-442, March 1981.

Pater, L., "Far field Overpressure from TNT Explosions: A Survey of Available Models," Naval Surface Weapons Center, TR-81-132, April 1981.

Pater, L., Eric Sandeen, George Swenson, Jr., Kenneth McK. Eldred, Raman Yousefi and Walter Alvendia, "Comparison of Barriers and Partial Enclosures for Rifle Range Noise Reduction," USACERL Technical Report EC-94/19, May 1994.

Pater, L., Walter Alvendia, Raman Yousefi and James Wilcoski, "Acoustic Spectral Emission Data for Several Small Weapons," USACERL Technical Report, in manuscript, to be published in 1999.

Pierce, A. D., <u>Acoustics, An Introduction to Its Physical Principles and Applications</u>, Acoustical Society of America, 1989.

Piercy, J. E., T. Embleton and L. Sutherland, "Review of Noise Propagation in the Atmosphere," J. Acoust. Soc. Am., 61, 1403-1418, June 1977.

Rice, C. "CEC Joint Research on Annoyance due to Impulse Noise: Laboratory Studies," <u>Noise as a Public Health Problem: Proceedings of the Fourth International Congress, Volume 2</u>, G. Rossi, Editor, Cetnro Ricerche E Studi Amplifon, Milan, Italy, pages 1073-1084, 1983.

Rice, C.., I. Flindell and J. John, "Annoyance due to Impulse Noise: Laboratory Studies, Final Report, CEC Third Programme, Phase 2, 1984-85," Contract Report 86/13, Institute of Sound and Vibration Research, University of Southampton, July 1986.

Schomer, P. D., "Predicting Community Response to Blast Noise," USACERL Technical Report E-17, December 1973.

Schomer, P. D., R. J. Goff and L. M. Little, "The Statistics of Amplitude and Spectrum of Blasts Propagated in the Atmosphere - Vol. I," USACERL Technical Report N13, November 1976.

Schomer, P. D., R. J. Goff and L. M. Little, "The Statistics of Amplitude and Spectrum of Blasts Propagated in the Atmosphere - Vol. II: Appendices C through E," USACERL Technical Report N13, November 1976.

Schomer, P. D., et. al., "Blast Noise Prediction Volume 1: Data Bases and Computational Procedures," USACERL Technical Report N-98, March 1981.

Schomer, P. D., L. M. Little and A. B. Hunt, "Acoustic Directivity Patterns for Army Weapons," USACERL Technical Report N-60, January 1979.

Schomer, P. D., "Acoustic Directivity Patterns for Army Weapons: Supplement 1," USACERL Technical Report N-60, September 1982.

Schomer, P. D., "Acoustic Directivity Patterns for Army Weapons: Supplement 2," USACERL Technical Report N-60, August 1984.

Schomer, P. D. and S. S. Goebel, "Acoustic Directivity Patterns for Army Weapons: Supplement 3: The Bradley Fighting Vehicle," USACERL Technical Report N-60, April 1985.

Schomer, P. D., "Acoustic Directivity Patterns for Army Weapons: Supplement 4: The Mulltiple Launch Rocket System," USACERL Technical Report N-60, February 1986.

Schomer, P. D., "High-energy Impulsive Noise Assessment," J. Acoust. Soc. Am., 79(1), 182-186, January 1986.

Schomer, P. D., L. Wagner, L. Benson, E. Buchta, K.-W. Hirsch and D. Krahe, "Human and community response to military sounds: Results from field-laboratory tests of small-arms, tracked-vehicle, and blast sounds," Noise Control Engineering Journal, Vol 42, 71-84, 1994.

Schomer, P., "New Descriptor for High-Energy Impulsive Sounds," Noise Control Eng. J. 42(5), 179-191, 1994.

Schultz, T.J., "Synthesis of Social Surveys on Noise Annoyance," J. Acoust. Soc. Am., 64, 377-405, 1978.

Sorenson and Magnusson, "Annoyance caused by noise from shooting range," Journal of Sound and Vibration, 62, 437-442, 1979.

U.S. Code of Federal Regulations, Title 14, Part 150. "Airport Noise Compatibility Planning," 1980.

Vos, J. "A review of research on the annoyance caused by impulse sounds produced by small firearms," Proceedings of INTER-NOISE 95: Vol 2, Noise Control Foundation: New York, 875-878, 1995.

Walther, M. F., "Gun Blast from Naval Guns," NWL Technical Report TR-2733, Naval Weapons Laboratory, August 1972.

White, M.J. and K.E. Gilbert, "Application of the parabolic equation to the outdoor propagation of sound," Applied Acoustics 27(3), 227-238, 1989.

White, M. J., C. R. Shaffer and R. Raspet, "Measurements of Blast Noise Propagation over Water at Aberdeen Proving Ground, MD," USACERL Technical Report EAC-93/02, September 1993.

APPENDIX A: WOODPECKER AUDIOGRAM CONTRACT REPORT

WOODPECKER AUDIOGRAM CONTRACT REPORT

Introduction

As a means of estimating the hearing ability of the Red-cockaded Woodpecker (RCW) (*Picoides borealis*), we have begun testing the hearing of a closely-related surrogate species, the downy woodpecker (*P. pubescens*). As the closest relative of the RCW, downy woodpeckers serve as an excellent example for a first approach to investigating hearing in RCWs. We will also be testing another close relative, the hairy woodpecker *(P. villosus)* as we are able to capture them during the course of the next several months. As an additional comparison and control with the woodpeckers, we have been testing budgerigars (*Melopsittacus undulatus*), another small, non-passerine bird. Budgerigars are a readily available laboratory study species, and the hearing abilities of budgerigars are well-known. Our goal is to provide a generalized audiogram for small woodpeckers that would include the hearing ability of the RCW.

Methods

Thus far we have captured two individual downy woodpeckers (a male and a female), and we have obtained usable data from one of these birds (the female). Results reported below indicate our best estimate of woodpecker hearing abilities based on data obtained from this individual, and will be supplemented as we continue capturing and testing birds. Downy woodpeckers are obtained locally using baited feeders and mist nets (all appropriate permits and animal-use protocols have been obtained and adhered to). This procedure allows woodpeckers to be captured and secured with minimal stress and injury. Budgerigars may be either store-bought pet varieties, or members of a breeding flock captured and imported from their native Australia. Hearing abilities for domestic and wild type budgerigars are similar. Budgerigars have been tested repeatedly in our procedures over the course of this year.

An audiogram may be determined in several ways. The most accurate technique is known as a "behavioral audiogram" and involves training an individual to perform specific behaviors in response to auditory stimuli. This technique requires considerable time and effort to allow animals to adjust to captivity and learn the appropriate behaviors (usually as a conditioned response to food reward), and is therefore impractical as a rapid, first assessment of hearing ability in captive wild woodpeckers. However, over an appropriate time course and with sufficient habituation to a captive situation, this technique may prove to be feasible in small woodpeckers. Another method for estimating hearing abilities involves measurement of electrical activity in the auditory nerve. This technique requires surgical access to peripheral hearing structures, and while possible in a surrogate species, is not likely to be useful for application to RCWs. A third method for obtaining an audiogram involves the measurement of "evoked potentials" on the surface of the skull. This is a non-invasive technique, and may ultimately be useful for testing RCWs themselves. Evoked potentials occur as a consequence of underlying neural activity resulting from auditory stimuli. Specifically, the short-term "auditory brainstem response" (ABR) is an evoked response that has proved useful in obtaining hearing threshold data in small birds. While less accurate than behavioral methods, evoked potential techniques such as the ABR enable hearing abilities to be tested relatively quickly. It is therefore our method of choice for obtaining initial hearing threshold data for small woodpeckers.

Measuring ABR in small birds

To obtain ABR recordings in small birds, birds are first anesthetized lightly using a mixture of ketamine and diazepam. Once sedated, a bird is secured to a foam pad and Grass pin electrodes are placed under the surface of the skin on the scalp. The active electrode is placed at the vertex of the skull and the reference electrode is placed in the skin just dorsal and posterior to the ear that will receive the auditory stimuli. A ground electrode is placed under the skin on the opposite side of the head from the reference electrode. Stimuli are clicks and tone bursts, delivered either in the free field from one side of the bird or via a Pilot funnel attached to the speaker and placed next to the external opening of the bird's ear. Results and calibrations are similar for these two methods, and results obtained using the Pilot funnel delivery method are reported here.

We use 5 ms alternating phase tone bursts with 2 ms cosine-ramped rise/fall times delivered at a rate of 20 per second. Responses are collected for 20 ms following each tone burst. Birds are tested at the following frequencies: 300 Hz, 500 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 2860 Hz, 4000 Hz, 5700 Hz, and 8000 Hz. Click stimuli are 0.1 ms onset / offset pulses (also alternating in phase) delivered in the same way at a rate of 5 per second. Sound generation and waveform averaging are controlled with Tucker-Davis Technologies hardware modules and software running on a Pentium 133 microcomputer. Tones and clicks are calibrated before and after each recording session using a Larson-Davis System 824 sound level meter. Stimuli are recorded and examined using the sound level meter and the SIGNAL sound analysis software package.

Estimating thresholds

Thresholds are estimated using peak-to-peak waveform amplitude of the ABR, as it varies with stimulus intensity. A regression line is fitted to this amplitude versus intensity function and the intensity intercept of the regression line used as an estimate of relative auditory threshold. Because such thresholds for tone bursts differ by an absolute value of roughly 25 dB from auditory thresholds determined behaviorally, we adjusted the auditory thresholds using the click stimulus as a measure of "best response"(since click stimuli produce a more robust response in the ABR). An example ABR response to a click stimulus across different intensity levels is given in Figure A1. In this figure, each tracing represents 20 ms following the onset of the click. We subsequently adjusted our tone stimulus thresholds by an amount equivalent to the difference between our click threshold and the absolute value of the best frequency tone burst threshold (and adjusted all other tone stimulus thresholds accordingly).

Results

Using the method described above, Figure A2 shows an estimate of best auditory threshold in our woodpecker based on the click ABR. Our regression indicates a best sensitivity of 24.4 dB, approximately 20 dB higher than that for budgerigars.

Adjusting the absolute values of tone stimulus thresholds in the manner described above produces an audiogram for the woodpecker from which we were able to obtain tone and click threshold data. This preliminary audiogram is shown in Figure A3. Bearing in mind that results reported here are an estimation from one bird, it appears that the shape of the woodpecker audiogram

is roughly comparable to that of the budgerigar and those of small passerine birds in general. Woodpeckers may be somewhat less sensitive in

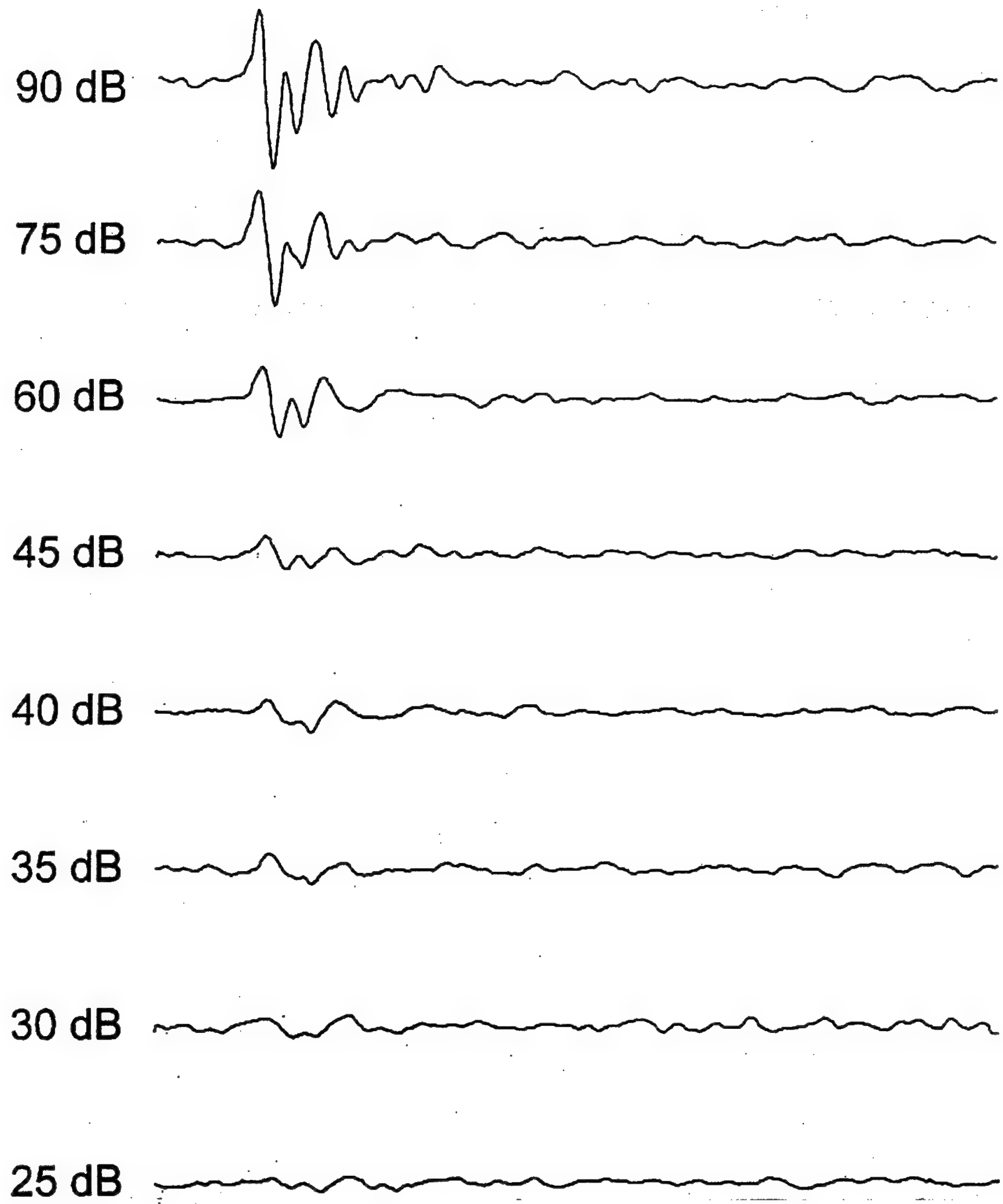

Figure A1. Example ABR Response.

absolute terms (a higher threshold at best frequency), and appear to have somewhat greater sensitivity at relatively lower frequencies compared to the budgerigar (frequency of best sensitivity is lower). Neither budgerigars nor woodpeckers exhibit much sensitivity at the lowest tested frequency of 300 Hz. Both species showed no sensitivity at all to 8000 Hz tones using the ABR technique. Behavioral thresholds for budgerigars are typically at least 50 - 60 dB higher at this frequency than at their best frequency (approximately 2860 Hz), possibly accounting for our lack of response, with the generally less sensitive ABR method of estimating hearing thresholds.

What might account for the higher threshold at best frequency for this downy woodpecker when compared with budgerigars? One potential explanation derives from our technique of measuring evoked potentials at the surface of the skull. The skull is generally much thicker in woodpeckers than in budgerigars. An increased skull thickness is likely to be a protective adaptation for drumming and other percussive behaviors in woodpeckers. It remains to be determined whether such adaptations also include a reduction in auditory sensitivity compared with other small birds, or skull thickness (or perhaps an active

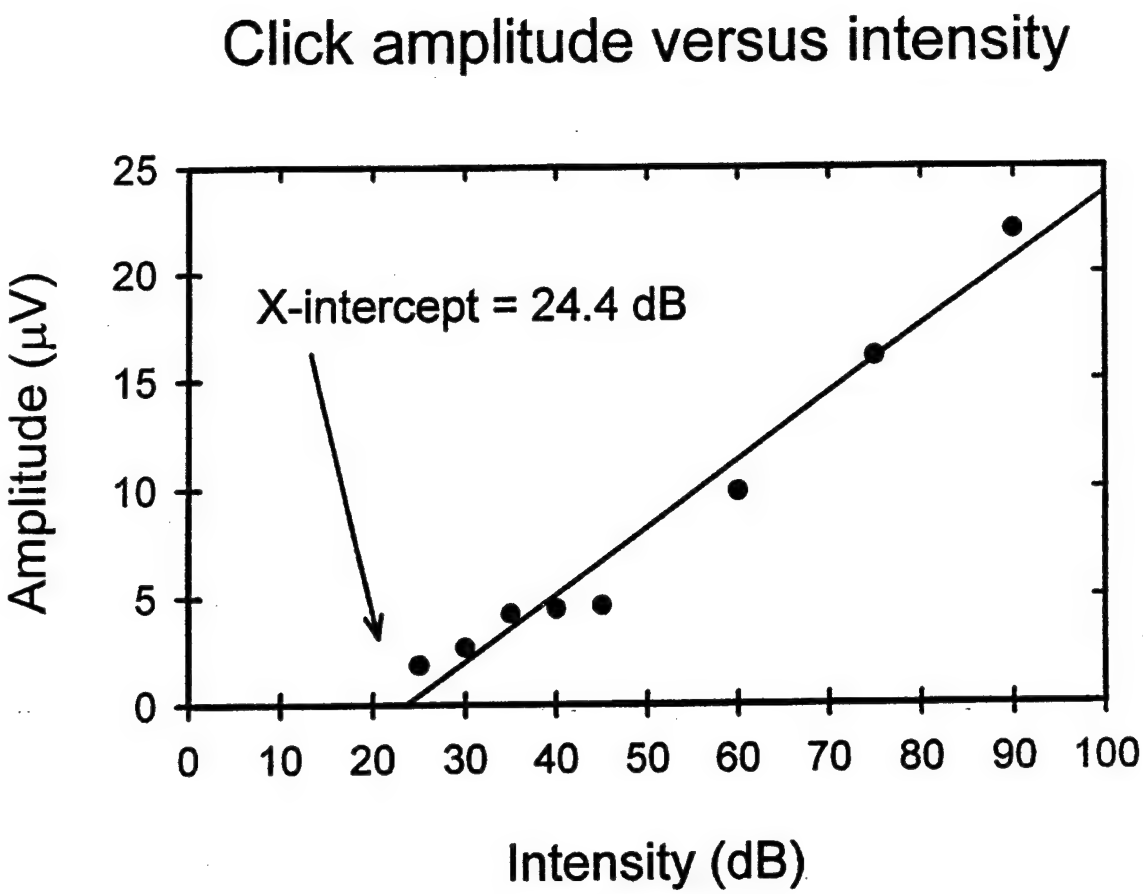

Figure A2. Example Best Auditory Threshold Regression.

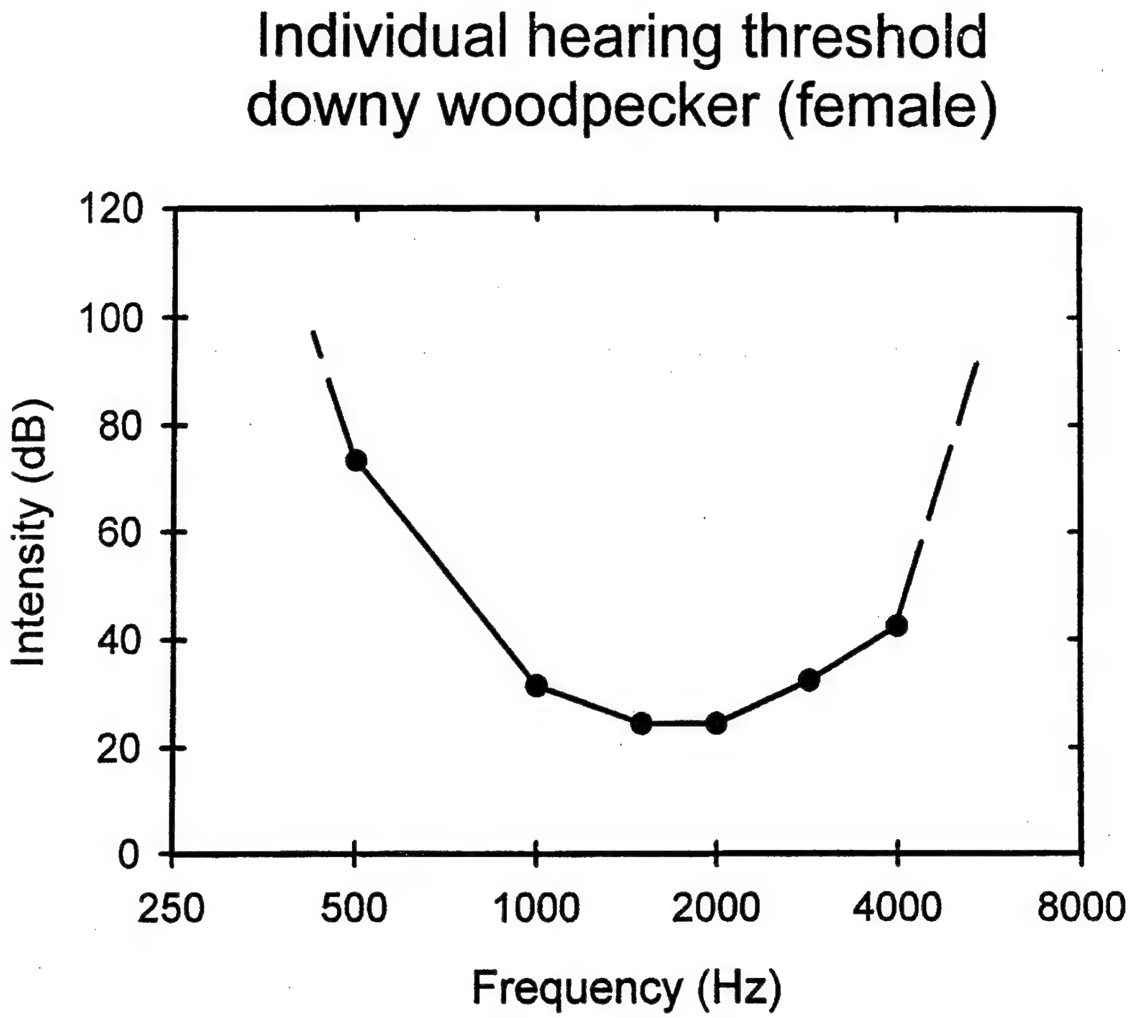

Figure A3. Preliminary Estimate of Downy Woodpecker Audiogram.

hearing protective mechanisms in the woodpecker auditory system) prevent us from measuring true tone thresholds using the ABR technique. We have planned additional tests, involving invasive recordings beneath the skull with a bird or two, and experiments involving deeper anesthetics in an attempt to illuminate this issue. Another potential confounding effect at low frequencies (500 - 1000 Hz), is the presence of an artifact that partially obscures the ABR waveform. At present, we have eliminated potential noise sources, and believe that this constitutes a frequency-following response in the bird. While this waveform artifact does not preclude the determination of thresholds from low frequency waveforms, it may result in greater variation from measurements taken at those frequencies. Further modifications are planned to address this issue as well. As we obtain more birds and continue testing, we can provide more confident assessments of the actual thresholds involved for small woodpeckers and their relationship to thresholds already determined for other species of small birds.

APPENDIX B: SUMMARY DATA TABLES

Table A1. Flush response of nesting Red-cockaded Woodpeckers versus the number, distance and noise level of large caliber live fire on Fort Stewart, Georgia, 1998.

Stimulus Distance (m)	Cluster Tested	Number of Noise Events	Number of Data Sessions	Number of Flushes	Noise Levels, SEL (dB) unweighted	Noise Levels, SEL (dB) "A" weighted	Typical Ambient LEQ (dB) "A" weighted
500	83	73	2	2	97.7 - 107.6	77.5 - 95.4	41.7 - 54.1
1800-2000	62, 48	6	3	None	90.1 - 97.4	52.1 - 77.3	37.9 - 46.0
3000-3600	83, 172, 184	19	3	None	83.6 - 95.8	47.7 - 67.6	28.6 - 43.3
3900-4000	84, 177	35	3	None	62.8 - 85.4	38.2 - 66.3	31.8 - 32.8
4500-5300	9, 48, 55, 159	75	4	None	60.2 - 85.5	48.0 - 71.4	40.1 - 42.2
5800-6000	41, 47	30	2	None	58.9 - 72.0	42.1 - 54.0	35.1 - 49.4
7200-7500	62, 67, 76, 218	83	4	None	61.0 - 78.6	36.2 - 48.8	33.8 - 46.4
9000-9500	36, 48, 62, 67, 75, 84, 179, 187, 203	116	10	None	75.1 - 83.6	44.4 - 58.2	36.6 - 53.5
10300-10600	48, 75, 76, 159, 172, 184, 187, 218	122	9	None	67.1 - 76.6	37.4 - 43.0	33.1 - 43.3
11000-12500	9, 37, 142, 152, 159, 183, 187, 216	58	9	None	58.0 - 69.3	36.1 - 54.5	33.9 - 46.2
Totals	**25**	**617**	**48**	**2**			

Table A2. Flush response of nesting Red-cockaded Woodpeckers versus the number, distance and noise level of small caliber live fire on Fort Stewart, Georgia, 1998.

Stimulus Distance (m)	Cluster Tested	Number of Noise Events	Number of Data Sessions	Number of Flush Responses	Noise Levels, SEL (dB) unweighted	"A" weighted	Typical Ambient LEQ (dB) "A" weighted
800-1000	51	91	1	None	67.1-67.5	59.2 - 59.9	37.7
1200-1400	9, 23	52	1	None	57.2 - 57.6	47.6 - 50.9	39.4
2000-2600	26, 61	97	2	None	49.5 - 57.7	31.5 - 41.6	32.3 - 34.0
2800-4000	26, 86, 133	17	4	None	52.7 - 60.6	34.4 - 43.8	32.3
5600-5800	2	5	1	None	75.1 - 75.9	60.4 - 63.4	41.6
8000-10000	48, 61, 76, 172, 177, 187, 194	69	7	None	Noise levels at these distances were difficult to distinguish from ambient levels		32.8 - 46.2
10001-12000	48, 67, 142	13	2	None	Same as above		30.7 - 41.8
Totals	**12**	**344**	**18**	**None**			

Table A3. Flush response of nesting Red-cockaded Woodpeckers versus the number, distance and noise level of helicopter flyovers on Fort Stewart, Georgia, 1998. Stimulus distance represents the closest estimated approach distance by a helicopter.

Stimulus Distance (m)	Cluster Tested	Number of Noise Events	Number of Data Sessions	Number of Flushes	Noise Levels, SEL (dB) unweighted	Noise Levels, SEL (dB) "A" weighted	Typical Ambient LEQ (dB) "A" weighted
40-60	83	1	1	None	106.3	91.9	41.7
100-200	62, 83, 203	3	3	None	98.2 - 104.1	87.7 - 93.8	41.7 - 46.0
250-300	48, 83	3	3	None	96.3 - 97.6	80.9 - 87.0	41.7 - 41.8
500	26, 142	2	2	None	72.5 - 78.0	55.8 - 56.6	34.0 - 37.1
Totals	**6**	**9**	**9**	**None**			

Table A4. Flush response of nesting Red-cockaded Woodpeckers versus the number, distance and noise level of military vehicles on Fort Stewart, Georgia, 1998. Stimulus distance represents the closest estimated approach distance by military vehicles.

Stimulus Distance (m)	Cluster Tested	Number of Noise Events	Number of Data Sessions	Number of Flushes	Noise Levels, SEL (dB) unweighted	Noise Levels, SEL (dB) "A" weighted	Typical Ambient LEQ (dB) "A" weighted
15-60	47, 83, 179, 203, 216,	8	6	None	83.1 - 106.6	65.9 - 95.0	35.1 - 45.5
150-250	47, 48, 62, 75, 127, 136, 172, 183, 216,	32	9	None	98.2 - 104.1	87.7 - 93.8	41.7 - 46.0
400-500	51, 172, 183, 218	6	4	None	96.3 - 97.6	80.9 - 87.0	41.7 - 41.8
Totals	**14**	**46**	**19**	**None**			

Table A5. Flush response of nesting Red-cockaded Woodpeckers versus the number, distance and noise level of artillery simulators on Fort Stewart, Georgia, 1998.

Stimulus Distance (m)	Cluster Tested	Number of Noise Events	Number of Data Sessions	Number of Flushes	Noise Levels, SEL (dB) unweighted	Noise Levels, SEL (dB) "A" weighted	Typical Ambient LEQ (dB) "A" weighted
1600-1800	172	3	1	None	74.4 - 82.2	57.1 - 72.2	36.4
2800-3000	86	2	1	None	63.9 - 64.1	56.4 -56.6	37.7
3800-4000	133	1	1	None	63.3	41.7	41.3
6000-6200	172	2	1	None	58.8 - 58.9	38.6 - 40.4	35.4
Totals	**3**	**8**	**4**	**None**			

Table A6. Flush response of nesting Red-cockaded Woodpeckers versus the number, distance and noise level of MLRS on Fort Stewart, Georgia, 1998.

Stimulus Distance (m)	Cluster Tested	Number of Noise Events	Number of Data Sessions	Number of Flushes	Noise Levels, SEL (dB) unweighted	Noise Levels, SEL (dB) "A" weighted	Typical Ambient LEQ (dB) "A" weighted
2000-2400	203	2	1	None	80.5 - 82.0	58.1 - 59.0	47.2
5300-5700	75	3	1	None	58.4 - 80.2	47.6 - 54.1	45.5
Totals	**2**	**5**	**2**	**None**			

Table A7. Flush response of nesting Red-cockaded Woodpeckers versus the number, distance and noise level of fixed-wing aircraft on Fort Stewart, Georgia, 1998. Stimulus distance represents the closest estimated approach distance by airplanes.

Stimulus Distance (m)	Cluster Tested	Number of Noise Events	Number of Data Sessions	Number of Flushes	Noise Levels, SEL (dB) unweighted	"A" weighted	Typical Ambient LEQ (dB) "A" weighted
501-1000	47, 51, 62, 83, 127, 136, 159, 174, 218	12	13	None	78.9 - 93.4	67.4 - 82.8	34.4 - 47.6
Totals	**9**	**12**	**13**	None			

Table A8. Flush response of nesting Red-cockaded Woodpeckers versus the number, distance and noise level of small arms blank fire on Fort Stewart, Georgia, 1998.

Stimulus Distance (m)	Cluster Tested	Number of Noise Events	Number of Data Sessions	Number of Flushes	Noise Levels, SEL (dB) unweighted	"A" weighted	Typical Ambient LEQ (dB) "A" weighted
15.2	36, 37, 76, 142	243	4	1	78.9 - 93.4	67.4 - 82.8	34.4 - 47.6
Totals	**4**	**243**	**4**	**1**			

APPENDIX C: SOURCE SPECTRA EXAMPLES

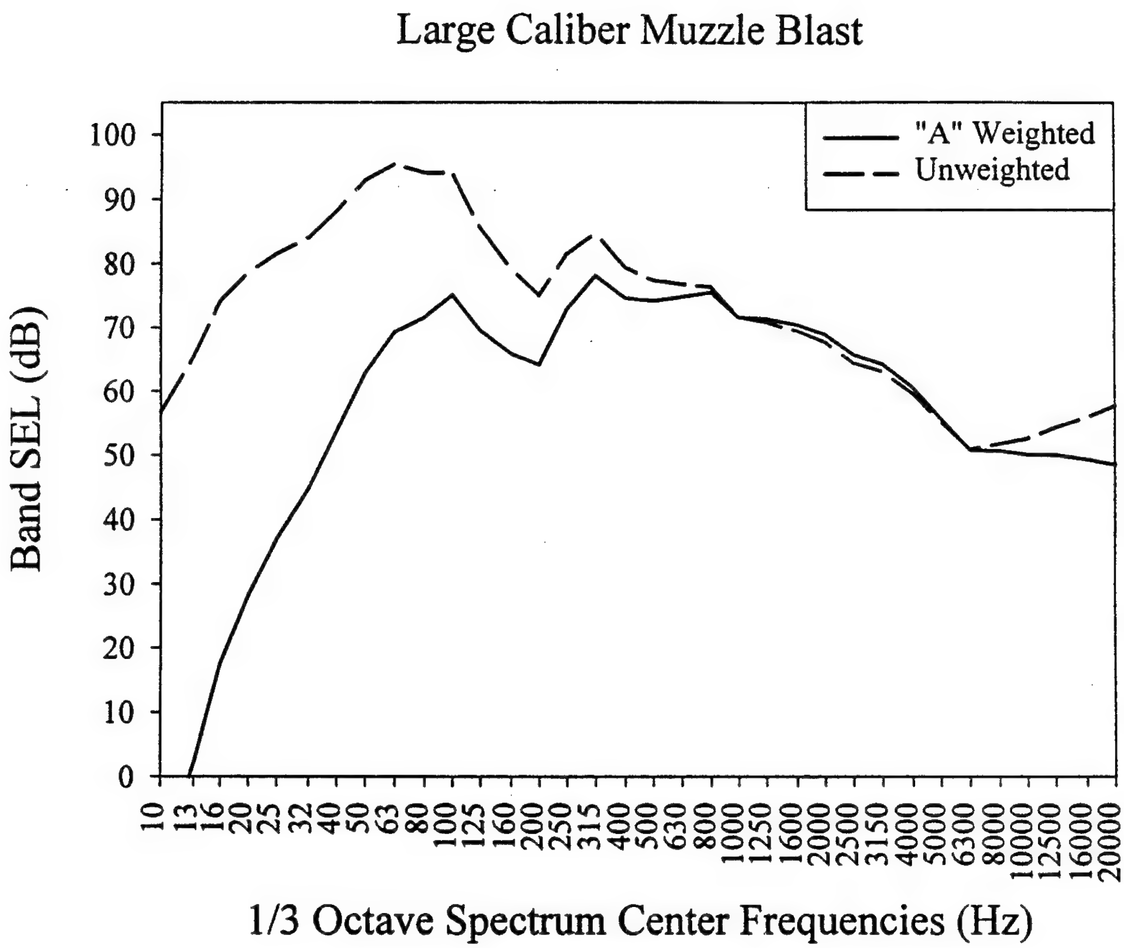

Figure C1. SEL weighting comparison for large caliber live fire at cluster 83 on 21 May 1998 (500 m).

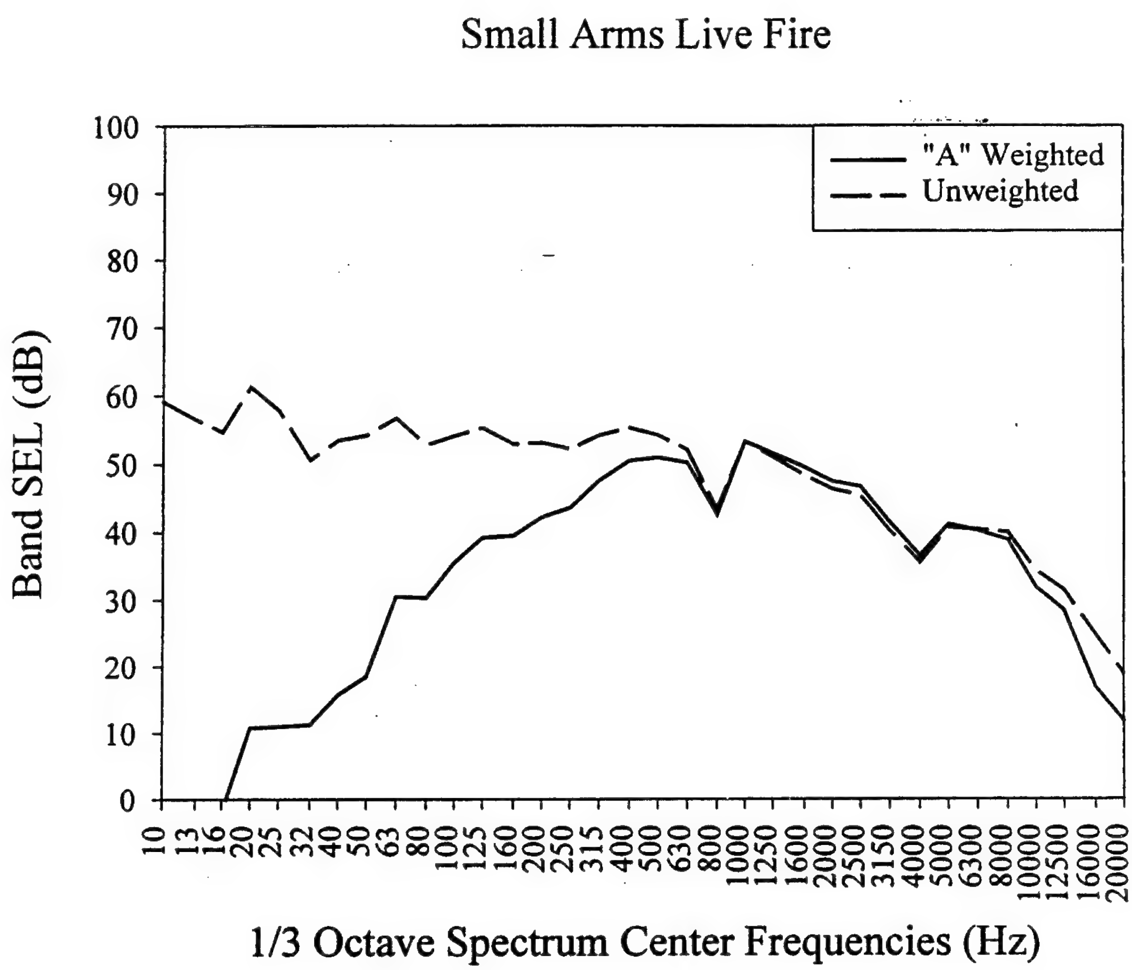

Figure C2. SEL weighting comparison for small arms live fire at cluster 51 on 5 May 1998 (M-16; 900 m).

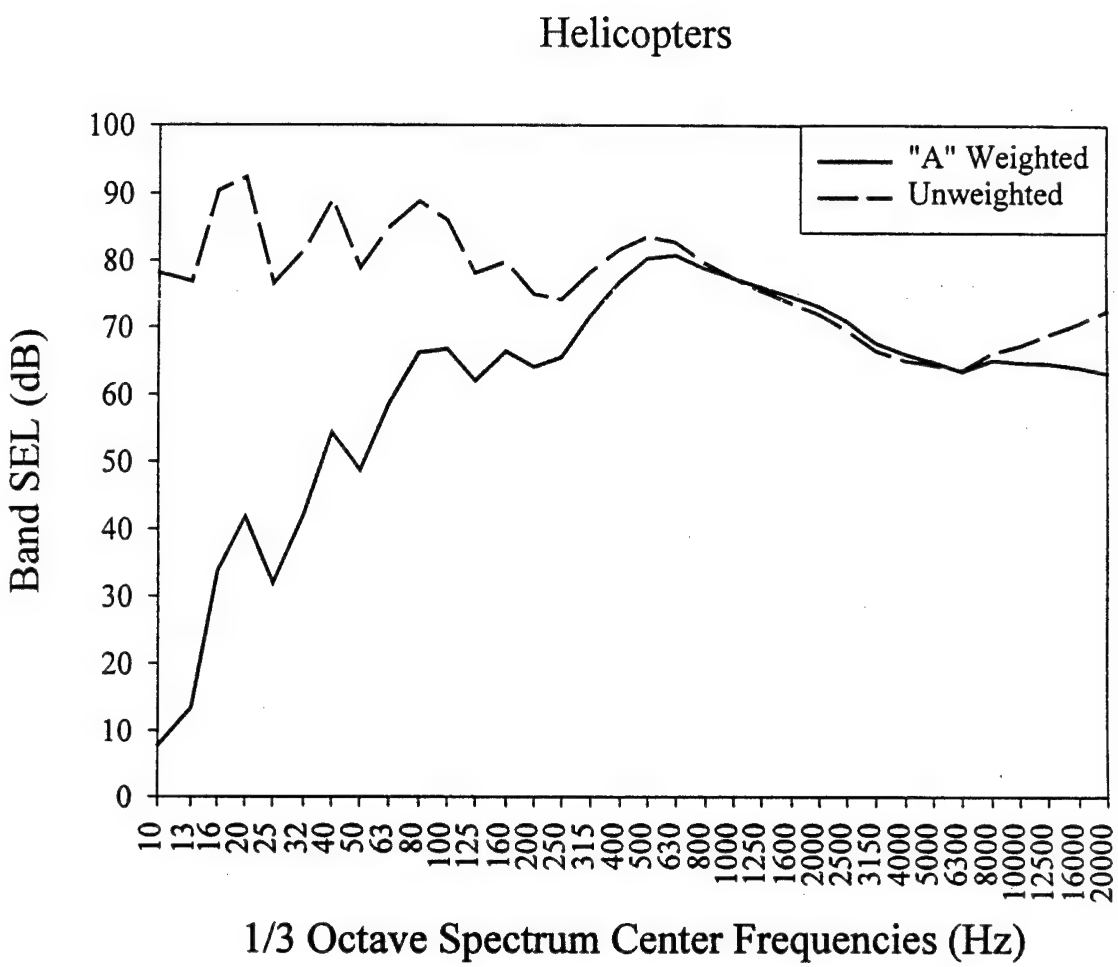

Figure C3. SEL weighting comparison for helicopters at cluster 83 on 21 May 1998 (40 m).

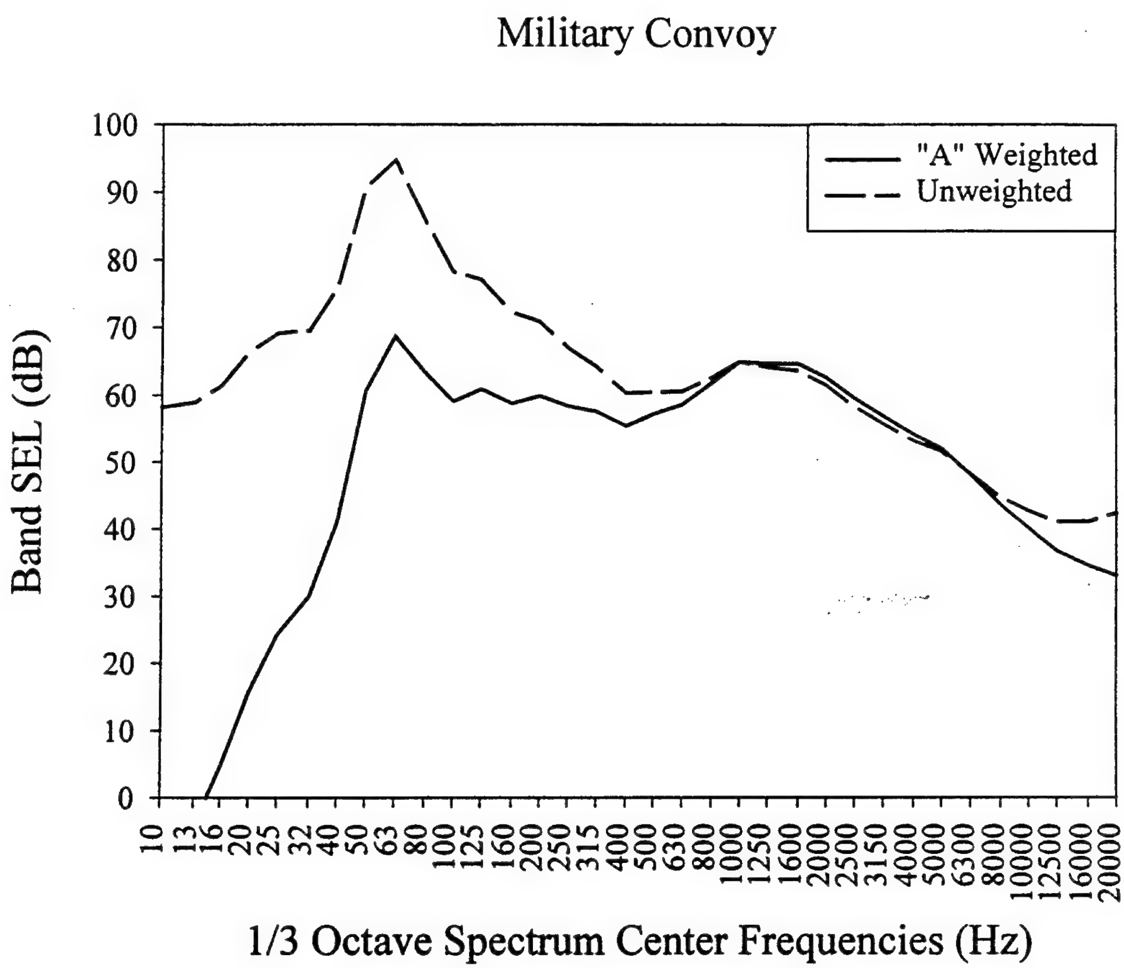

Figure C4. SEL weighting comparison for vehicle noise at cluster 47 on 5 May 1998 (60 m).

Fixed-wing Aircraft

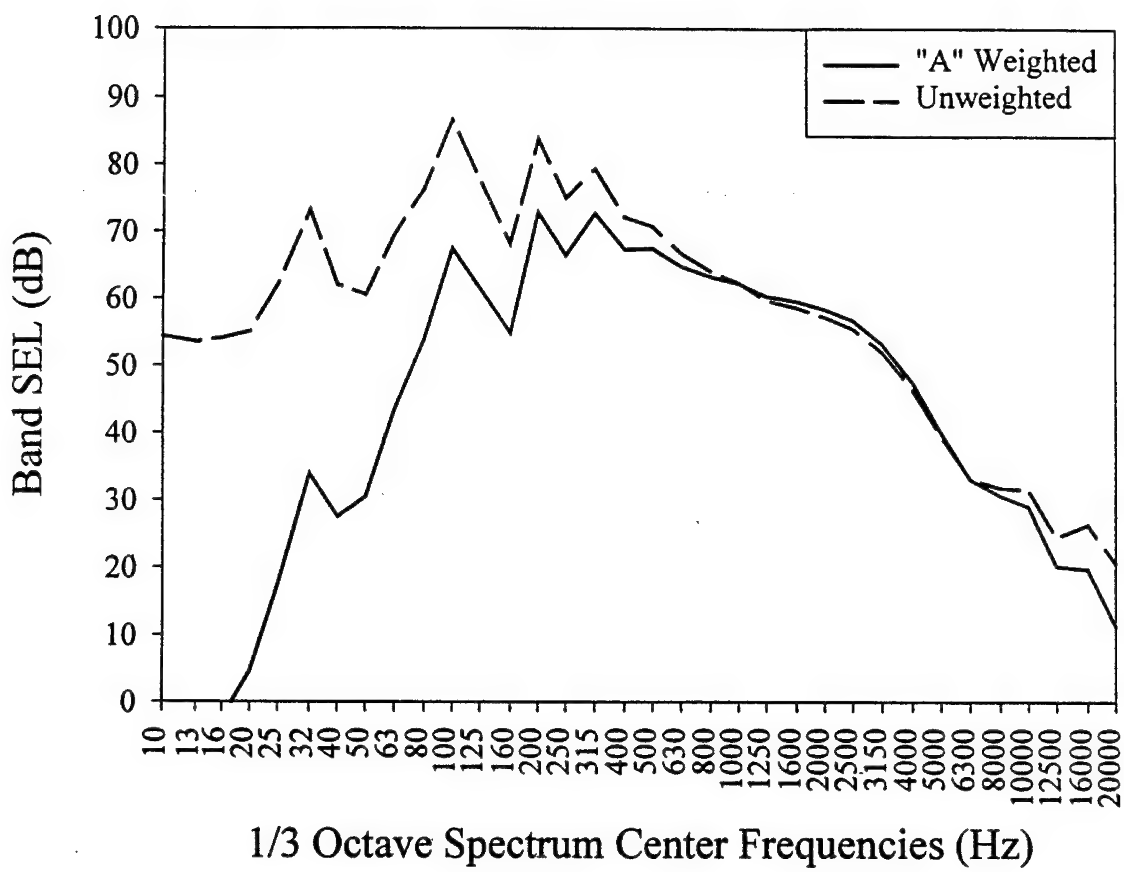

Figure C5. SEL weighting comparison for fixed-wing aircraft at cluster 51 on 15 May 1998 (600 m).

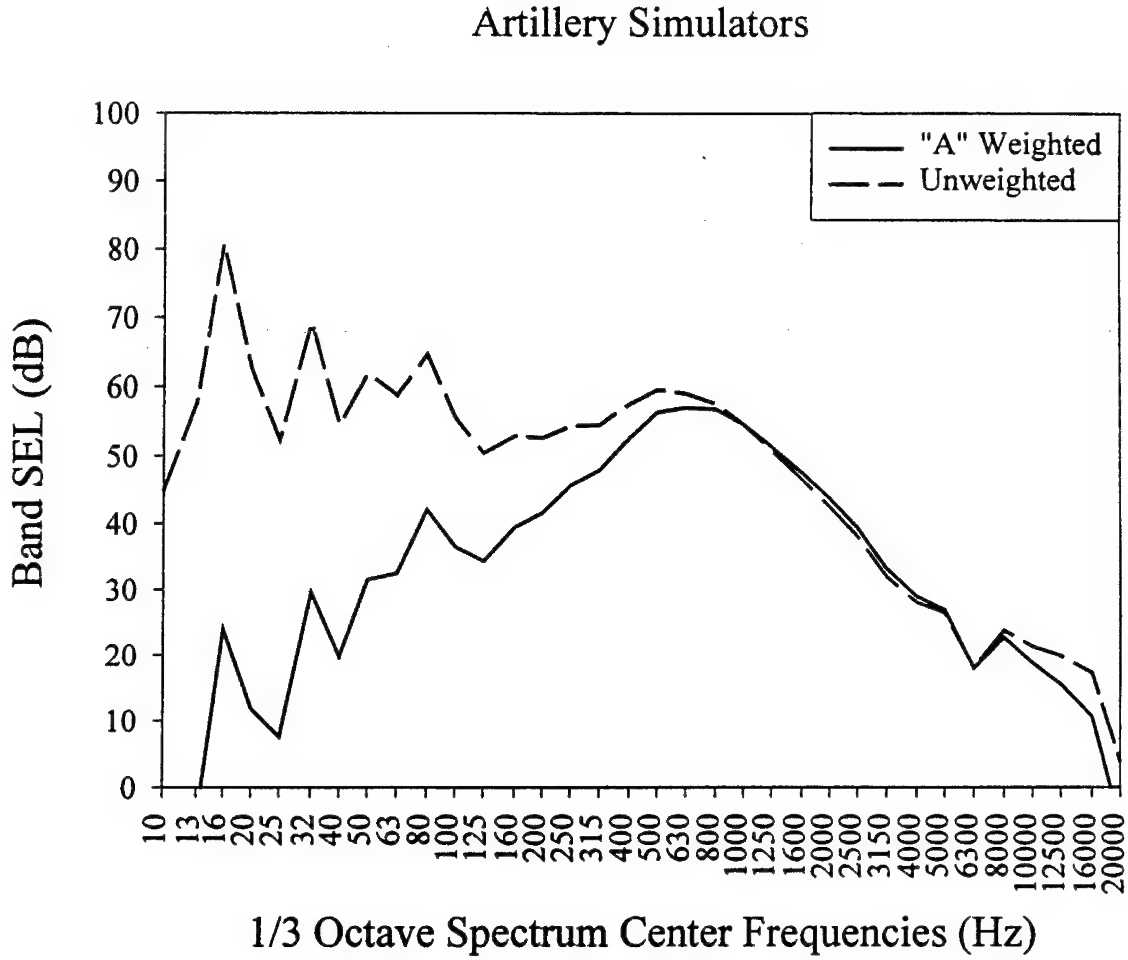

Figure C6. SEL weighting comparison for artillery simulators at cluster 172 on 21 May 1998 (1600 m).

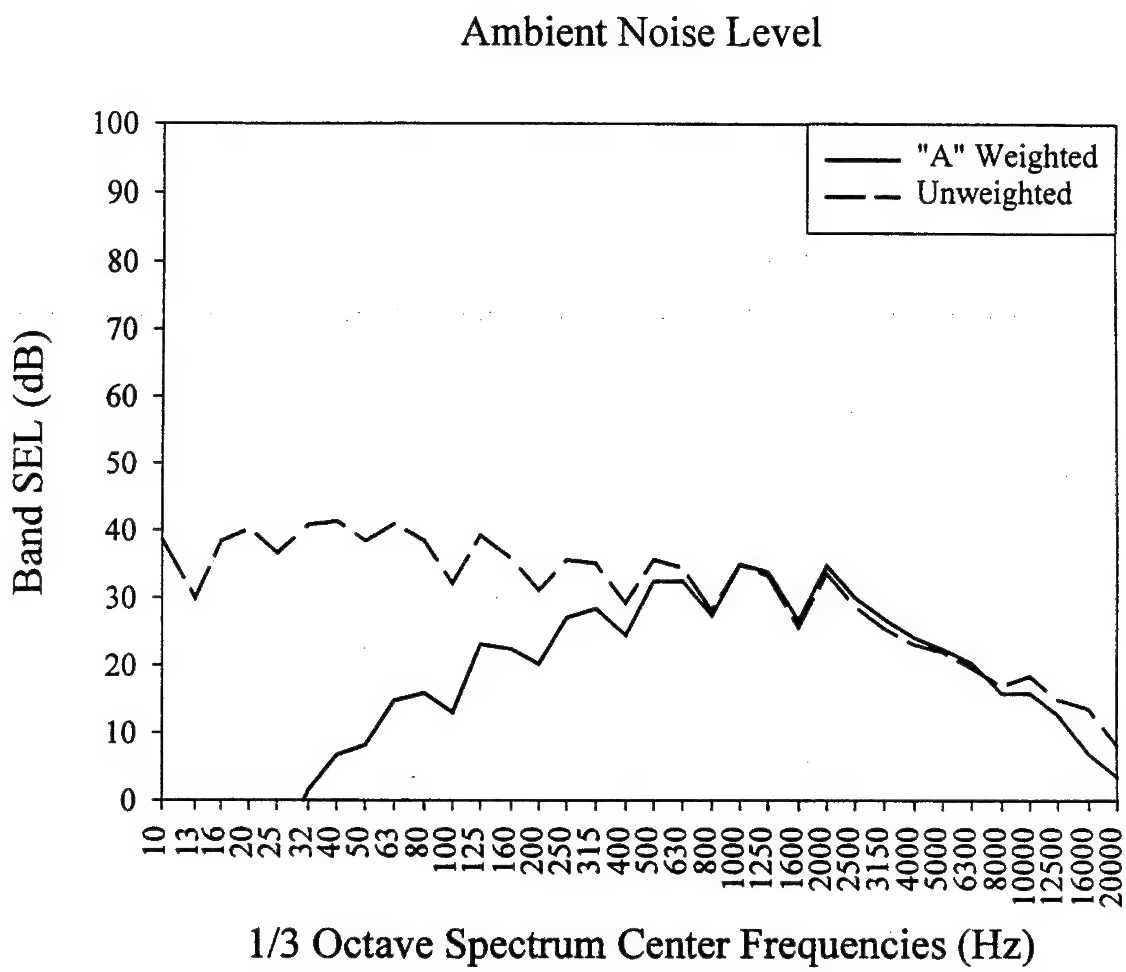

Figure C7. SEL weighting comparison for ambient noise levels at cluster 55 on 21 April 1998.

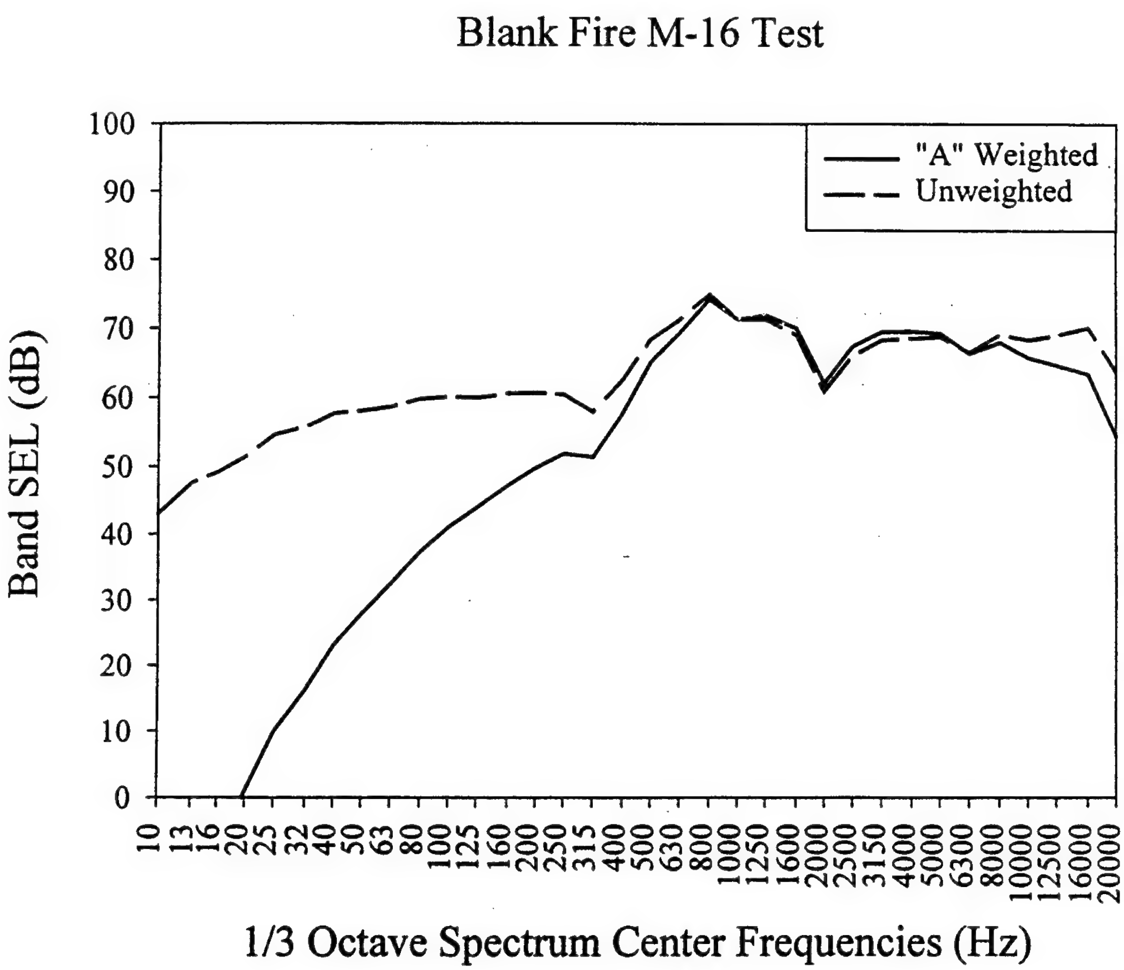

Figure C8. SEL weighting comparison for M-16 blank fire testing at cluster 142 on 3 June 1998 (15.2 m).

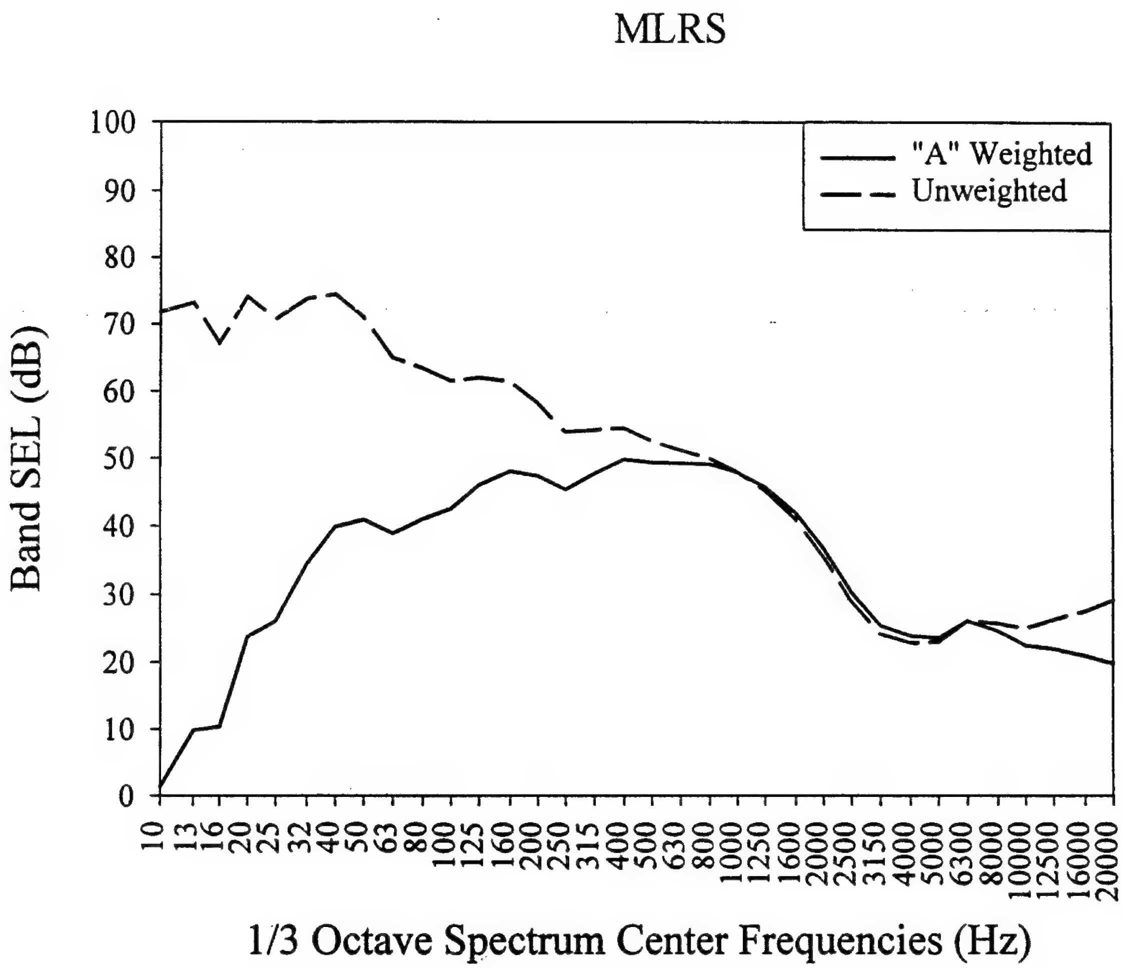

Figure C9. SEL weighting comparison for MLRS fire from cluster 203 on 20 May 1998 (2200 m).

APPENDIX D: SIGNIFICANT LEGAL REQUIREMENTS

SIGNIFICANT LEGAL REQUIREMENTS

The Endangered Species Act (ESA) requires federal agencies to carry out programs for the conservation of threatened and endangered species. They are further required to ensure that their actions do not jeopardize the continued existence of listed species or result in the destruction or adverse modification of the critical habitat of these species. These requirements fall under provisions of Section 7 of the Act, which also requires agencies to conduct biological assessments to evaluate the impacts of their activities on listed species. This assessment serves as the primary basis for coordination with the U.S. Fish and Wildlife Service which, in turn, issues a biological opinion and specific endangered species management recommendations. Implementation of these recommendations can place constraints on execution of the military mission. To avoid possible penalties resulting from findings of take due to harassment or harm resulting from exposure to military-related noise, a capability is needed to evaluate and monitor the impact of noise on both behavior and breeding success of affected species. Under the ESA it is the responsibility of the land owner, not of the USFWS, to evaluate effects of land use activities on threatened and endangered species.

The ESA prohibits take of endangered species, where "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Within the definition of "take", the term "harm" has been subject to significant judicial scrutiny. "Harm" is clearly an act that actually kills or injures wildlife, but it may also include actions that significantly impair essential behavioral patterns, including breeding, feeding, or sheltering.

The National Environmental Policy Act (NEPA) requires Federal Agencies to assess the impact of planned activities on the environment and to make the assessment available to the general public. The decision-making procedures are documented by either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). Noise and TES are often important issues in these, particularly as reviewers place a stronger emphasis on cumulative effects of activities.

APPENDIX E: DETAILED NOISE EVENT AND RCW RESPONSE DATA

Figure E1a. Summary data for Large Caliber Blast noise on Ft. Stewart, GA.

0 = no visible response

1 = alert to cavity mouth
2 = flush from cavity

Date	Cluster	Nesting Phase & Day	Event Type	Event Dist. (m)	Azimuth re. DOF	RCW Response	Recovery time (min)	Remarks	Mic Pos.	SEL (dB) at mic Flat	A
19-Jun-98	9	N-20	Explosion	5300	55	0			Base	81.8	48.0
19-Jun-98	9	N-20	Explosion	5300	55	0			Base	85.5	48.8
26-May-98	36	I-5	Tank blast	9500	30	0			Base	82.6	57.4
26-May-98	36	I-5	Tank blast	9500	30	0			Base	83.6	58.1
08-Jun-98	37	N-3	Tank blast	11200	60	0			Base	58.0	36.8
08-Jun-98	37	N-3	Tank blast	11200	60	0			Base	69.3	39.9
11-Jun-98	41	N-14	Tank blast	6000	100	0			Base	58.9	49.4
11-Jun-98	41	N-14	Tank blast	6000	100	0			Base	61.9	50.5
11-Jun-98	41	N-14	Tank blast	6000	100	0			Base	67.6	53.1
11-Jun-98	41	N-14	Tank blast	6000	100	0			Base	69.1	52.0
11-Jun-98	41	N-14	Tank blast	6000	100	0			Base	71.0	52.7
14-May-98	47	N-13	Tank blast	5800	90	0			Base	70.0	54.0
14-May-98	47	N-13	Tank blast	5800	90	0			Base	72.0	42.1
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	87.4	66.8
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	91.1	70.7
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	95.1	74.6
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	93.8	69.6
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	97.4	75.6
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	96.6	74.5
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	96.2	77.3
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	92.8	72.4
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	94.6	74.2
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	93.2	74.0
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	90.1	69.5
27-Apr-98	48	I-3	Artillery blast	3900	25	0			Base	93.9	74.4
19-May-98	48	N-13	Artillery blast	5000	90	0			Base	86.1	71.3
19-May-98	48	N-13	Artillery blast	5000	90	0			Base	87.7	71.4
19-May-98	48	N-13	Artillery blast	7900	50	0			Base	90.3	70.0
19-May-98	48	N-13	Artillery blast	7900	50	0			Base	89.8	70.3
19-May-98	48	N-13	Artillery blast	5000	25	0			Base	88.9	70.4

19-May-98	48	N-13	Artillery blast	5000	50	0			Base	85.8	66.3
19-May-98	48	N-13	Tank blast	3600	50	0			Base	85.8	67.3
19-May-98	48	N-13	Tank blast/explosion	3600	50	0			Base	77.0	58.2
19-May-98	48	N-13	Tank blast	3600	50	0			Base	75.1	57.7
21-Apr-98	55	N-1	Tank blast	4900	35	0			Base	78.8	52.0
21-Apr-98	55	N-1	Tank blast/explosion	4900	35	0			Base	73.6	50.9
21-Apr-98	55	N-1	Tank blast	4900	35	0			Base	60.2	48.3
21-Apr-98	55	N-1	Tank blast/explosion	4900	35	0			Base	75.2	52.8
21-Apr-98	55	N-1	Tank blast	4900	35	0			Base	60.7	52.9
21-Apr-98	55	N-1	Tank blast/explsion	4900	35	0			Base	76.9	52.9
21-Apr-98	55	N-1	Tank blast	4900	35	0			Base	67.9	53.3
21-Apr-98	55	N-1	Tank blast/explosion	4900	35	0			Base	80.0	52.8
27-Apr-98	62	I-2	Artillery blast	1800	70	0			Base	90.1	60.8
27-Apr-98	62	I-2	Artillery blast	1800	70	0			Base	90.1	60.7
14-May-98	62	N-3	Artillery blast	6600	70	0			Base	76.0	46.3
14-May-98	62	N-3	Artillery blast	6600	70	0			Base	78.6	37.8
14-May-98	62	N-3	Artillery blast	6600	70	0			Base	78.5	37.6
14-May-98	62	N-3	Artillery blast	6600	70	0			Base	77.4	42.5
14-May-98	62	N-3	Artillery blast	6600	70	0			Base	77.9	39.3
14-May-98	62	N-3	Artillery blast	6600	70	0			Base	74.8	40.0
21-May-98	62	N-10	Artillery blast	4500	90	0			Base	83.6	63.8
21-May-98	62	N-10	Artillery blast	1800	40	0			Base	95.5	54.1
21-May-98	62	N-10	Artillery blast	4500	90	0			Base	83.4	62.9
21-May-98	62	N-10	Artillery blast	1800	70	0			Base	91.7	52.1
28-Apr-98	67	I-5	25 mm	11500	50	0			Base	52.5	33.0
28-Apr-98	67	I-5	25 mm	11500	50	0			Base	57.7	34.0
28-Apr-98	67	I-5	25 mm	11500	50	0			Base	57.4	39.0
09-Jun-98	67	N-5	Tank blast	9500	50	0			Base	77.5	44.4
09-Jun-98	67	N-5	Tank blast	9500	50	0			Base	76.0	47.9
09-Jun-98	67	N-5	Impact noise	7500		0			Base	78.3	48.8
20-May-98	75	N-12	Impact noise	13000		0			Base	81.1	50.5
09-Jun-98	76	N-7	Impact noise	7500		0			Base	69.4	38.1
09-Jun-98	76	N-7	Impact noise	7500		0			Base	75.2	37.7

09-Jun-98	76	N-7	Impact noise	7500		0			Base	76.9	42.5
09-Jun-98	76	N-7	Impact noise	7500		0			Base	74.6	40.8
09-Jun-98	76	N-7	Impact noise	7500		0			Base	76.7	41.4
09-Jun-98	76	N-7	Impact noise	7500		0			Base	75.5	41.2
09-Jun-98	76	N-7	Impact noise	7500		0			Base	76.8	47.3
09-Jun-98	76	N-7	Impact noise	7500		0			Base	76.9	45.0
09-Jun-98	76	N-7	Impact noise	7500		0			Base	77.7	45.6
09-Jun-98	76	N-7	Tank blast	10300	40	0			Base	76.4	41.5
20-May-98	83	I-2	Artillery blast	500	60	0			Base	102.6	78.0
20-May-98	83	I-2	Artillery blast	500	60	0			Base	95.3	69.9
20-May-98	83	I-2	Artillery blast	500	60	0			Base	102.5	82.6
20-May-98	83	I-2	Artillery blast	500	60	0			Base	95.1	72.7
20-May-98	83	I-2	Artillery blast	500	60	0			Base	102.5	77.5
20-May-98	83	I-2	Artillery blast	500	60	0			Base	95.1	69.3
20-May-98	83	I-2	Artillery blast	500	60	2	6.25	returns 10:11:55	Base	107.6	87.7
20-May-98	83	I-2	Artillery blast	500	60	0			Base	106.4	87.0
21-May-98	83	I-3	Artillery blast	500	60	0			Base	103.6	88.7
21-May-98	83	I-3	Artillery blast	500	60	0			Base	104.6	90.3
21-May-98	83	I-3	Artillery blast	500	60	2	4.42		Base	105.4	90.9
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.9	88.0
21-May-98	83	I-3	Artillery blast	500	60	0			Base	105.0	90.7
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.8	94.6
21-May-98	83	I-3	Artillery blast	3200	20	0			Base	94.1	64.0
21-May-98	83	I-3	Artillery blast	500	60	0			Base	100.4	81.4
21-May-98	83	I-3	Artillery blast	3200	20	0			Base	93.2	65.3
21-May-98	83	I-3	Artillery blast	3200	20	0			Base	95.8	67.6
21-May-98	83	I-3	Artillery blast	3200	20	0			Base	92.9	62.4
21-May-98	83	I-3	Artillery blast	3200	20	0			Base	93.6	61.8
21-May-98	83	I-3	Artillery blast	3200	20	0			Base	94.0	64.8
21-May-98	83	I-3	Artillery blast	500	60	0			Base	100.1	84.0
21-May-98	83	I-3	Artillery blast	500	60	0			Base	100.9	88.4
21-May-98	83	I-3	Artillery blast	500	60	0			Base	100.4	83.4
21-May-98	83	I-3	Artillery blast	500	60	0			Base	100.6	79.4
21-May-98	83	I-3	Artillery blast	500	60	0			Base	98.1	84.3
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.0	85.5
21-May-98	83	I-3	Artillery blast	500	60	0			Base	99.8	82.1

21-May-98	83	I-3	Artillery blast	500	60	0			Base	100.0	85.9
21-May-98	83	I-3	Artillery blast	500	60	0			Base	99.3	87.0
21-May-98	83	I-3	Artillery blast	500	60	0			Base	105.2	92.2
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.5	86.8
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.0	89.6
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.8	94.6
21-May-98	83	I-3	Artillery blast	500	60	0			Base	101.1	84.4
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.0	85.5
21-May-98	83	I-3	Artillery blast	500	60	0			Base	96.2	82.3
21-May-98	83	I-3	Artillery blast	500	60	0			Base	104.9	86.5
21-May-98	83	I-3	Artillery blast	500	60	0			Base	104.6	87.8
21-May-98	83	I-3	Artillery blast	500	60	0			Base	103.4	87.3
21-May-98	83	I-3	Artillery blast	500	60	0			Base	97.7	78.5
21-May-98	83	I-3	Artillery blast	500	60	0			Base	99.6	80.5
21-May-98	83	I-3	Artillery blast	500	60	0			Base	100.4	82.9
21-May-98	83	I-3	Artillery blast	500	60	0			Base	101.2	85.3
21-May-98	83	I-3	Artillery blast	500	60	0			Base	99.9	83.0
21-May-98	83	I-3	Artillery blast	500	60	0			Base	97.3	82.6
21-May-98	83	I-3	Artillery blast	500	60	0			Base	99.8	82.9
21-May-98	83	I-3	Artillery blast	500	60	0			Base	99.8	82.9
21-May-98	83	I-3	Artillery blast	500	60	0			Base	97.9	83.0
21-May-98	83	I-3	Artillery blast	500	60	0			Base	100.0	84.9
21-May-98	83	I-3	Artillery blast	500	60	0			Base	104.4	95.4
21-May-98	83	I-3	Artillery blast	500	60	0			Base	103.3	87.9
21-May-98	83	I-3	Artillery	500	60	0			Base	92.9	66.0
21-May-98	83	I-3	Artillery	500	60	0			Base	103.0	87.1
21-May-98	83	I-3	Artillery	500	60	0			Base	103.1	87.5
21-May-98	83	I-3	Artillery	500	60	0			Base	104.5	89.6
25-May-98	83	I-7	Tank blast	11800	45	0			Base	74.0	46.7
25-May-98	83	I-7	Explosion	7500	0	0			Base	74.5	38.8
25-May-98	83	I-7	Tank blast	11800	45	0			Base	74.2	40.3
25-May-98	83	I-7	Explosion	7500		0			Base	64.7	43.7
21-May-98	84	N-19	Blast			0			Base	71.8	56.2
21-May-98	84	N-19	Blast			0			Base	73.5	54.9
28-Apr-98	142	I-6	25 mm fire	12700	55	0			Base	61.1	40.7
28-Apr-98	142	I-6	25 mm fire	12700	55	0			Base	58.4	40.6
28-Apr-98	142	I-6	25 mm fire	12700	55	0			Base	58.1	41.6

28-Apr-98	142	I-6	25 mm	12700	55	0			Base	64.2	37.2
28-Apr-98	142	I-6	25 mm	12700	55	0			Base	64.0	39.2
28-Apr-98	142	I-6	25 mm	12700	55	0			Base	57.5	36.7
28-Apr-98	142	I-6	25 mm	12700	55	0			Base	58.0	36.1
22-May-98	152	N-10	Artillery Impact noise	12900		0			Base	60.9	40.5
20-Apr-98	169	No-nest	Artillery blast	4100		non-nesting			Base	88.3	52.0
20-Apr-98	169	No-nest	Artillery blast	4100		non-nesting			Cavity	87.0	62.7
20-Apr-98	169	No-nest	Artillery blast	4100		non-nesting			Cavity	88.0	67.2
20-Apr-98	169	No-nest	Artillery blast	4100		non-nesting			Base	89.4	58.5
23-Apr-98	172	I-6	Tank blast	10400	65	0			Base	68.5	53.2
23-Apr-98	172	I-6	Tank blast	10400	65	0			Base	74.0	53.4
19-May-98	172	N-22	Artillery blast	1800	70	0			Base	83.7	66.3
19-May-98	172	N-22	Artillery blast	1800	70	0			Base	83.6	61.1
19-May-98	172	N-22	Artillery blast	1800	70	0			Base	83.7	65.9
19-May-98	172	N-22	Artillery blast	1800	70	0			Base	83.7	66.2
19-May-98	172	N-22	Artillery Impact noise	12000		0			Base	73.2	37.3
19-May-98	172	N-22	Artillery Impact noise	10500		0			Base	76.6	37.4
19-May-98	172	N-22	Artillery blast	1800	70	0			Base	80.1	47.3
19-May-98	172	N-22	Artillery blast	3600	45	0			Base	77.0	47.7
19-May-98	172	N-22	Artillery blast	7200	100	0			Base	73.9	41.8
14-Jul-98	172	Post-fledging	25 mm	10300	120	Post-Fledgling			Cavity	82.5	74.4
14-Jul-98	172	Post-fledging	25 mm	10300	120	Post-Fledgling			Base	79.2	73.3
20-May-98	177	I-8	Tank blast/explosion	4000	150	0			Base	72.5	38.2
20-May-98	177	I-8	Tank blast/explosion	4000	150	0			Base	80.9	48.8
27-May-98	177	I	Tank blast	4000	150	0			Base	62.8	45.5
27-May-98	177	I	Tank blast	4000	150	0			Base	84.1	53.3
27-May-98	177	I	Tank blast	4000	150	0			Base	85.4	66.3
17-May-98	179	N-25	Tank blat/explosion	9000	45	0			Base	82.3	47.1
26-May-98	179	N-25	Tank blast	9000	45	0			Base	86.8	43.7
26-May-98	179	N-25	Tank blast	9000	45	0			Base	86.5	47.1

26-May-98	179	N-25	Tank blast	9000	45	0			Base	87.3	48.6
21-May-98	183	N	Tank blast	11300	80	0			Base	83.0	66.5
21-May-98	183	N	Tank blast	11300	80	0			Base	63.7	54.6
04-May-98	184	N-3	Blast	5000	90	0			Base	84.4	51.6
04-May-98	184	N-3	Blast	5000	90	0			Base	86.7	52.1
04-May-98	184	N-3	Impact noise	12000		0			Base	65.8	36.8
11-Jun-98	187	N-16	Blast	4000		0			Base	79.7	45.9
11-Jun-98	187	N-16	25 mm	12000		0			Base	64.7	51.3
11-Jun-98	187	N-16	25 mm	12000		0			Base	63.7	50.3
11-Jun-98	187	N-16	25 mm	12000		0			Base	63.3	44.3
11-Jun-98	187	N-16	Tank	12000		0			Base	79.4	45.1
11-Jun-98	187	N-16	Tank	12000		0			Base	89.3	47.3
05-Jun-98	199	No-nest	Tank blast/explosion	4000		Non-nesting			Base	90.6	73.7
05-Jun-98	199	No-nest	Tank blast/explosion	4000		Non-nesting			Cavity	93.0	78.7
05-Jun-98	199	No-nest	Tank blast/explosion	4000		Non-nesting			Cavity	92.2	77.2
05-Jun-98	199	No-nest	Tank blast/explosion	4000		Non-nesting			Base	91.7	73.0
05-Jun-98	199	No-nest	Tank blast/explosion	4000		Non-nesting			Base	90.6	78.3
05-Jun-98	199	No-nest	Tank blast/explosion	4000		Non-nesting			Cavity	92.2	79.4
05-Jun-98	199	No-nest	Tank blast/explosion	4000		Non-nesting			Cavity	91.8	79.9
05-Jun-98	199	No-nest	Tank blast	4000		Non-nesting			Base	90.1	74.5
19-May-98	216	N-16	Artillery blast			0			Base	72.7	54.0
19-May-98	216	N-16	Artillery blast			0			Base	87.9	70.1
19-May-98	216	N-16	Artillery blast			0			Base	87.0	43.8
19-May-98	216	N-16	Artillery blast			0			Base	86.6	43.8
19-May-98	216	N-16	Artillery blast			0			Base	87.8	68.7
14-May-98	218	N-14	Tank blast/explosion	7300	80	0			Base	70.3	36.4
14-May-98	218	N-14	Tank blast	7300	80	0			Base	66.8	36.2
14-May-98	218	N-14	Tank blast/explosion	7300	80	0			Base	75.6	39.7

14-May-98	218	N-14	Tank blast/explosion	7300	80	0			Base	77.9	42.2
14-May-98	218	N-14	Tank blast	7300	80	0			Base	61.0	36.8
14-May-98	218	N-14	Tank blast/explosion	7300	80	0			Base	74.2	42.7
14-May-98	218	N-14	Tank blast	7300	80	0			Base	65.6	37.4
14-May-98	218	N-14	Tank blast/explosion	7300	80	0			Base	72.6	40.1
21-May-98	218	N-21	Artillery Impact noise	10600		0			Base	67.1	40.6
21-May-98	218	N-21	Artillery Impact noise	10600		0			Base	71.7	43.0
14-Jul-98	Buelah	n/a	25 mm	6200		n/a			n/a	61.0	44.3
15-Jul-98	Buelah	n/a	Tank blast	8800	105	n/a			n/a	87.0	52.4
21-May-98	83	I-3	Artillery blast	500	60	0			Base	104.0	87.1
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.9	89.3
21-May-98	83	I-3	Artillery blast	500	60	0			Base	101.9	80.3
21-May-98	83	I-3	Artillery blast	500	60	0			Base	99.0	78.9
21-May-98	83	I-3	Artillery blast	500	60	0			Base	101.9	87.9
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.6	84.2
21-May-98	83	I-3	Artillery blast	500	60	0			Base	102.5	85.8
21-May-98	83	I-3	Artillery blast	500	60	0			Base	98.5	80.9

Figure E1b. This sheet contains the representative unweighted spectra Blast noise on Ft. Stewart, GA.

Date	Col	Event Type	Event Dist. (m)	Mic Pos.	Band SEL (dB) at 1/3 Octave Spectrum Center Frequencies (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400
6/19	9	Explosion	5300	Base	77	78	71	70	68	68	63	67	64	61	58	55	51	43	35	33	32
6/19	9	Explosion	5300	Base	81	81	78	73	66	65	70	66	67	63	55	52	49	41	35	33	33
5/26	36	Tank blast	9500	Base	76	79	77	69	50	56	58	59	59	57	53	56	53	52	54	53	-224
5/26	36	Tank blast	9500	Base	79	77	79	73	60	61	58	61	58	58	56	58	53	41	53	52	44

Date	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	Calc. Overall SEL
6/19	32	32	30	32	32	30	32	32	29	31	31	29	31	31	29	31	29	81.8
6/19	33	33	32	33	33	33	34	33	32	33	33	32	33	33	32	32	31	85.5
5/26	53	48	43	48	48		46	44		44	37		35	38				82.6
5/26	52	50	37	49	51	47	45	44		41	40		39	39		26		83.6

6/8	37	Tank blast	11200	Base	49	48	53	48	48	47	46	43	42	42	38	36	31	26	27	27	27	27	24	6	24	23		23	22		22	20	30	32	18		10	-3	58.0
6/8	37	Tank blast	11200	Base	64	63	63	61	57	52	45	45	47	45	36	39	38	38	37	35	30	30	28	24	25	25	19	21	21	23	27	26	32	33	17		9	-3	69.3
6/11	41	Tank blast	6000	Base			46	45		46	53		49	46	48	49	47		41	43		42	43		43	41		31	37		37	31		28	33		22		58.9
6/11	41	Tank blast	6000	Base	43	53	53	40		57	49		49	53		49	47		47	42		42	44		43	45		35	37		36	29		31	34		25		61.9
6/11	41	Tank blast	6000	Base	59	56	59	58		54	58	57	56	52	54	54	52		49	48	30	47	47	39	45	44		39	39		37	33		28	28		25		67.6
6/11	41	Tank blast	6000	Base	55	56	57	63	60	59	61	58	54	51	50	52	50	28	48	46	41	45	45		46	42		40	39		35	35		25	32		28		69.1
6/11	41	Tank blast	6000	Base	56	54	57	62	62	65	65	58	54	56	53	52	49	49	44	48	43	46	46		45	44		41	40		36	32			31		-234		71.0
5/14	47	Tank blast	5800	Base	55	55	65	63	63	60	52	49	52	48	44	53	51	41	49	47		48	47		47	46	28	44	40		39	36		28	24		24		70.0
5/14	47	Tank blast	5800	Base	64	58	66	66	66	59	49	50	49	48	49	49	47	42	38	33	29	25	24	23	22	21	24	29	28	29	26	24	31	30	24	25	26	27	72.0
4/27	48	Artillery blast	3900	Base	75	76	78	75	73	73	77	78	76	78	80	74	69	67	63	62	59	58	56	52	49	46	38	40	39	28	33	33	22	28	31		24		87.4
4/27	48	Artillery blast	3900	Base	74	80	80	73	76	79	82	80	80	85	82	80	72	69	69	65	63	61	59	56	53	49	43	42	42	34	37	36	16	31	31		24		91.1
4/27	48	Artillery blast	3900	Base	79	83	83	82	82	86	83	84	86	86	88	83	77	73	73	70	66	64	61	59	56	52	47	43	43	37	38	38	22	31	31		26		95.1
4/27	48	Artillery blast	3900	Base	77	80	81	79	76	82	83	89	86	84	80	77	70	69	65	62	60	58	58	52	50	45	39	40	40	32	35	35	26	30	29		22		93.8
4/27	48	Artillery blast	3900	Base	76	79	83	82	82	85	88	89	90	90	87	84	77	74	72	70	66	64	62	59	55	51	44	44	42	35	38	37	28	32	33	23	27	16	97.4
4/27	48	Artillery blast	3900	Base	79	82	82	80	81	84	88	90	87	90	86	85	77	73	68	66	64	61	60	57	54	50	44	43	41	33	37	36	30	28	33	20	23		96.6
4/27	48	Artillery blast	3900	Base	73	78	81	79	80	82	82	83	87	91	90	85	79	76	77	73	67	65	63	60	57	52	48	46	46	39	40	39	32	33	35	20	30		96.2
4/27	48	Artillery blast	3900	Base	75	77	80	79	78	80	81	81	86	86	84	81	74	71	69	67	64	62	61	58	54	50	45	43	43	35	39	37	23	32	31		26		92.8
4/27	48	Artillery blast	3900	Base	82	81	76	81	82	83	84	84	85	87	87	83	75	71	70	69	66	65	62	59	56	51	45	40	38	36	35	34	29	29	30		20	10	94.6
4/27	48	Artillery blast	3900	Base	70	77	76	75	75	76	79	79	83	89	87	83	75	73	69	67	65	63	61	57	52	48	43	37	36	31	31	31	26	25	27	15	20		93.2
4/27	48	Artillery blast	3900	Base	70	77	74	74	75	77	74	75	84	86	80	78	68	66	68	64	60	60	59	54	50	45	39	32	29	29	28	28	28	30	31	33	34	36	90.1
4/27	48	Artillery blast	3900	Base	75	79	79	77	77	79	80	79	84	89	87	84	76	74	70	68	66	64	61	58	53	48	43	35	32	34	31	31	32	33	34	36	37	39	93.9
5/19	48	Artillery blast	5000	Base	63	74	77	79	79	76	73	66	70	74	69	72	71	71	71	68	66	63	62	60	60	58	58	56	55	54	52	51	50	49	48	47	46	46	86.1
5/19	48	Artillery blast	5000	Base	79	80	78	76	80	78	75	66	74	70	72	70	72	71	70	67	64	63	63	60	60	59	58	56	56	54	53	52	51	50	48	47	46	45	87.7
5/19	48	Artillery blast	7900	Base	82	85	83	74	74	77	80	76	73	74	73	71	63	64	68	64	64	62	62	60	59	58	57	56	54	53	51	49	46	43	38	33	29	27	90.3
5/19	48	Artillery blast	7900	Base	81	84	82	76	78	80	81	76	73	67	74	69	64	70	66	65	64	63	62	61	60	59	57	56	55	54	52	50	49	46	43	38	31	26	89.8
5/19	48	Artillery blast	5000	Base	70	81	85	79	76	74	75	73	68	74	69	71	68	69	69	66	64	63	62	61	59	59	57	56	54	53	52	51	50	49	47	46	45	44	88.9
5/19	48	Artillery blast	5000	Base	70	69	76	78	79	79	75	66	67	71	69	69	68	66	65	62	57	59	58	56	55	53	52	51	49	48	47	45	44	43	42	41	40	40	85.8
5/19	48	Tank blast	3600	Base	71	73	73	75	80	79	77	70	67	72	71	67	68	68	65	63	60	60	59	57	55	54	53	51	50	49	48	46	45	44	43	42	42	43	85.8
5/19	48	Tank blast/explosion	3600	Base	63	65	63	64	66	68	67	66	67	67	65	64	63	60	56	54	50	49	49	47	45	41	37	34	30	24	26	25	23	21	18		13		77.0

5/19	48	Tank blast	3600	Base	59	63	64	65	63	61	64	65	63	63	65	66	63	60	55	52	49	49	47	46	45	40	37	34	30	24	24	25	15	19	18		14		75.1
4/21	55	Tank blast	4900	Base	74	73	69	66	62	65	69	63	62	59	58	55	50	47	48	48	47	46	44	43	41	38	25	35	33		25	27		20	22		16		78.8
4/21	55	Tank blast/explosion	4900	Base	66	64	67	65	59	59	62	61	60	60	57	54	47	47	48	45	46	46	44	42	40	37	25	32	29		25	25		21	20		14		73.6
4/21	55	Tank blast	4900	Base	40	43	41	45	46	46	51	49	51	54	50	47	46	45	43	42	43	42	42	41	37	35	31	28	28	23	28	28	28	31	32	33	35	37	60.2
4/21	55	Tank blast/explosion	4900	Base	68	65	69	67	61	62	64	62	62	62	59	55	49	49	49	47	47	47	45	44	41	38	35	31	30	27	31	32	32	34	35	36	38	40	75.2
4/21	55	Tank blast	4900	Base	44	39	36	44	45	45	50	51	49	49	48	46	48	50	47	47	50	47	47	46	43	40	36	32	29	26	27	28	28	31	32	33	35	37	68.7
4/21	55	Tank blast/explosion	4900	Base	71	68	66	69	65	67	65	65	64	61	58	55	49	49	49	48	48	47	45	44	41	38	34	32	31	29	31	31	31	33	35	36	38	40	76.9
4/21	55	Tank blast	4900	Base	48	46	49	55	57	57	56	57	60	60	58	55	53	50	47	48	47	47	47	46	43	40	37	32	29	25	28	28	28	31	32	33	35	37	67.9
4/21	55	Tank blast/explosion	4900	Base	75	74	70	67	63	66	70	64	64	61	59	57	51	48	48	49	48	47	45	44	40	37	33	30	30	27	31	31	31	34	35	36	38	40	80.0
4/27	62	Artillery blast	1800	Base	67	79	82	87	82	76	73	70	72	67	71	71	66	58	58	53	53	53	51	48	44	40	35	31	24	26	26	25		18	17		15		90.1
4/27	62	Artillery blast	1800	Base	67	79	82	87	82	76	73	70	72	67	70	71	66	58	58	53	53	53	51	48	44	40	34	27	32	25	22	24	24	24	26	27	29	30	90.1
5/14	62	Artillery blast	6600	Base	62	66	70	72	68	61	53	51	52	49	47	43	40	35	29	31	30	28	25	20	24	23	17	21	21	26	44	34	29	23	18		11	-1	76.0
5/14	62	Artillery blast	6600	Base	67	70	73	74	70	61	52	50	52	46	48	42	37	35	33	30	27	27	26	23	24	23	8	20	22	17	23	23	22	20	13		9		78.6
5/14	62	Artillery blast	6600	Base	66	72	74	73	66	55	48	53	51	48	47	43	38	34	31	29	27	27	27	22	25	24	17	22	22	5	19	20	19	21	14		13		78.5
5/14	62	Artillery blast	6600	Base	61	68	71	72	71	61	49	51	52	49	47	48	43	37	33	30	29	27	25	23	24	24	14	22	20	11	20	28	40	25	19		14		77.4
5/14	62	Artillery blast	6600	Base	65	69	72	73	71	62	53	51	53	50	49	47	42	35	33	30	28	29	26	21	26	24	18	22	21	10	19	22	22	18	12		11		77.9
5/14	62	Artillery blast	6600	Base	44	64	69	70	68	63	51	54	51	51	48	50	44	39	31	31	30	28	26	21	25	26	22	24	22	-1	18	14	-1	17	14		11		74.8
5/21	62	Artillery blast	4500	Base	52	57	58	62	65	70	74	74	77	77	77	73	66	58	52	51	51	51	52	52	51	50	47	46	43	35	37	33		31	31		17		83.6
5/21	62	Artillery blast	1800	Base	87	88	90	89	87	83	73	68	70	61	60	57	52	50	47	45	39	43	44	40	43	44	33	38	39		35	33		29	30		22		95.5
5/21	62	Artillery blast	4500	Base	41	56	61	65	66	69	75	75	76	77	76	72	61	53	47	50	49	51	50	51	49	50	47	46	42	33	34	29	20	23	29		24		83.4
5/21	62	Artillery blast	1800	Base	84	86	85	85	82	75	73	69	66	66	56	53	53	47	46	43	40	42	44	36	41	40	37	37	37		29	32		26	23		20		91.7
4/28	67	25 mm	11500	Base	49	48	38	41	39	33	32	30	29	24	21	25	21	15	23	26	27	28	27	26	24	23	11	19	17		16	11		9	10		10		52.5
4/28	67	25 mm	11500	Base	33	39	37	42	47	52	53	50	44	46	40	35	32	29	27	25	25	27	27	23	24	21	15	19	17	7	17	13		11	11		12		57.7
4/28	67	25 mm	11500	Base	54	50	50	44	40	37	34	32	32	30	29	28	29	28	31	32	35	34	34	32	29	27	14	22	20		18	15		14	14		13		57.4
6/9	67	Tank blast	9500	Base	72	73	71	65	61	56	55	59	58	53	50	47	48	45	40	40	36	33	30	27	26	23	23	33	24	14	30	34	27	30	31	7	12		77.5
6/9	67	Tank blast	9500	Base	71	69	63	57	68	67	64	63	52	53	53	47	47	43	44	40	42	38	34	29	27	24	22	27	37	29	30	41	33	38	28	20	28	28	76.0
6/9	67	Impact noise	7500	Base	72	71	68	64	69	71	68	64	59	60	59	51	49	49	48	44	45	42	37	33	29	27	22	24	24	13	20	19		18	15		13	1	78.3
5/20	75	Impact noise	13000	Base	72	74	77	74	72	63	56	57	56	56	53	54	51	49	47	48	48	46	43	40	35	31	26	26	26	14	21	20		14	15		15	-1	81.1
6/9	76	Impact noise	7500	Base	59	65	63	60	53	57	58	55	50	48	48	42	35	36	34	33	30	27	26	21	21	22	14	19	19	14	18	24	29	22	13	6	19	25	69.4

6/9	76	Impact noise	7500	Base	70	71	69	62	58	55	54	50	45	45	45	39	37	34	32	33	32	30	26	18	24	22	12	17	17		19	19	29	29	17	12	23	23	75.2
6/9	76	Impact noise	7500	Base	71	72	71	63	61	64	61	56	46	52	49	48	42	40	37	37	37	36	32	27	26	25	20	22	21		22	23	31	32	20	12	25	31	76.9
6/9	76	Impact noise	7500	Base	65	71	69	58	61	63	61	54	45	52	47	44	38	39	36	37	36	34	31	26	24	23	19	22	21	1	19	22	29	27	15	4	18	24	74.6
6/9	76	Impact noise	7500	Base	70	73	70	63	64	64	60	55	45	53	45	47	42	39	37	38	37	35	31	25	23	23	17	19	18	7	19	23	29	26	15		10	2	76.7
6/9	76	Impact noise	7500	Base	70	71	66	60	63	61	63	56	46	54	49	45	42	38	36	36	35	34	30	24	23	22	14	20	20		20	22	32	31	17		13	11	75.5
6/9	76	Impact noise	7500	Base	69	72	72	68	60	61	58	54	46	51	46	47	42	39	37	37	37	36	34	28	27	26	22	28	28	23	29	38	43	42	29	23	22	16	76.8
6/9	76	Impact noise	7500	Base	68	71	72	69	63	56	60	51	45	48	48	47	40	39	34	36	36	35	33	28	26	24	21	24	28	28	32	34	39	38	27	21	20	15	76.9
6/9	76	Impact noise	7500	Base	71	73	70	65	67	67	62	61	51	56	51	49	42	40	39	40	40	39	37	34	32	29	23	24	24	18	26	30	35	34	21	4	22	24	77.7
6/9	76	Tank blast	10300	Base	70	72	69	64	63	62	60	54	46	49	45	44	40	36	35	35	36	36	35	32	29	26	19	21	20		18	19	29	29	16		20	20	76.4
5/20	83	Artillery blast	500	Base	82	86	89	91	94	94	96	96	90	83	83	84	78	76	73	72	69	66	71	67	67	64	63	62	60	58	55	51	46	43	40	30	26	19	102.6
5/20	83	Artillery blast	500	Base	90	87	87	83	80	80	86	79	84	81	77	78	70	67	64	68	67	62	58	52	50	47	39	41	40	31	42	46	33	39	46	19	28		95.3
5/20	83	Artillery blast	500	Base	81	85	88	91	94	95	96	96	90	82	80	84	83	78	78	77	76	75	74	73	72	71	70	69	68	65	64	62	60	58	56	52	48	42	102.5
5/20	83	Artillery blast	500	Base	84	84	86	82	82	88	87	78	82	84	83	79	73	68	67	70	70	66	63	58	53	52	46	44	42	34	40	45	27	39	45	21	25	16	95.1
5/20	83	Artillery blast	500	Base	83	86	90	92	95	96	95	94	89	82	76	82	82	75	71	74	71	69	67	66	66	65	63	61	60	57	54	51	46	42	39	28	23		102.5
5/20	83	Artillery blast	500	Base	87	87	88	80	81	85	78	82	84	84	78	77	72	68	63	63	63	61	58	55	51	49	43	43	42	32	37	39	23	36	42		26		95.1
5/20	83	Artillery blast	500	Base	86	92	94	98	100	100	101	100	93	89	86	88	87	83	84	84	81	79	80	77	78	76	74	74	71	67	67	65	62	60	59	56	52		107.6
5/20	83	Artillery blast	500	Base	89	90	93	95	97	99	100	100	93	88	85	88	87	84	87	84	81	80	78	77	75	73	72	70	68	65	61	58	56	51	46	40	38	29	106.4
5/21	83	Artillery blast	500	Base	85	89	92	93	92	90	90	89	92	92	98	93	86	79	83	89	81	82	80	77	76	75	73	71	69	67	63	60	52	51	47	41	41	35	103.6
5/21	83	Artillery blast	500	Base	83	91	95	97	96	94	91	89	94	92	95	93	86	82	84	88	85	82	81	80	80	80	79	76	73	71	68	68	65	60	60	56	52	44	104.6
5/21	83	Artillery blast	500	Base	87	90	93	94	93	93	94	95	99	96	95	89	88	83	87	88	88	83	82	82	79	80	76	75	73	70	69	65	61	58	55	50	47	43	105.4
5/21	83	Artillery blast	500	Base	73	88	92	94	93	90	90	92	94	94	92	90	86	77	80	87	82	80	81	78	77	75	74	72	72	68	66	63	59	57	53	48	43	32	102.9
5/21	83	Artillery blast	500	Base	82	87	87	88	94	95	96	98	98	93	95	89	86	87	85	84	85	85	83	81	81	78	79	78	73	72	68	65	61	59	55	50	47	38	105.0
5/21	83	Artillery blast	500	Base	73	77	79	84	86	88	91	91	89	95	94	92	85	85	89	94	91	91	85	84	80	80	82	78	78	77	75	74	72	71	69	67	65	61	102.8
5/21	83	Artillery blast	3200	Base	85	87	87	88	86	79	70	69	71	65	63	62	60	57	56	56	53	53	50	47	50	49	45	50	50	46	51	52	51	54	56	57	59	61	94.1
5/21	83	Artillery blast	500	Base	85	88	88	87	87	85	89	92	94	92	90	87	75	75	76	78	77	75	71	71	68	66	64	62	58	56	55	54	53	56	57	59	61	63	100.4
5/21	83	Artillery blast	3200	Base	85	87	87	87	81	68	67	73	74	67	69	66	61	57	58	59	58	57	53	50	51	50	47	50	50	45	52	52	51	55	56	57	59	61	93.2
5/21	83	Artillery blast	3200	Base	86	89	89	89	88	82	74	72	70	68	69	65	63	60	60	60	59	58	56	52	54	53	48	52	53	49	55	55	55	58	59	60	62	64	95.8
5/21	83	Artillery blast	3200	Base	82	87	87	86	83	78	72	72	70	66	68	66	62	56	55	54	54	53	50	47	47	47	42	47	47	43	48	49	48	52	53	54	56	58	92.9
5/21	83	Artillery blast	3200	Base	86	87	87	88	83	78	73	70	69	65	68	64	60	54	52	53	51	51	48	45	48	47	42	47	47	41	48	49	48	51	53	54	56	58	92.6

5/21	83	Artillery blast	3200	Base	84	87	87	88	86	84	78	76	70	72	73	67	70	57	58	61	58	57	51	48	48	48	43	45	47	42	48	49	48	52	53	54	56	58	94.0
5/21	83	Artillery blast	500	Base	87	89	91	89	93	91	87	88	88	88	86	84	80	76	80	80	83	77	76	72	71	71	71	66	64	61	57	55	53	55	56	57	59	61	100.1
5/21	83	Artillery blast	500	Base	84	88	90	87	91	89	89	89	90	90	92	90	83	76	83	81	84	85	79	78	78	77	74	74	72	69	65	62	58	60	58	58	59	61	100.9
5/21	83	Artillery blast	500	Base	89	91	94	89	87	84	86	89	90	87	90	88	81	73	75	78	80	78	72	73	71	69	69	69	69	65	63	59	57	57	56	57	59	61	100.4
5/21	83	Artillery blast	500	Base	88	91	93	90	93	91	87	88	88	87	85	84	78	72	77	73	74	72	71	69	68	67	65	64	62	58	56	54	52	55	56	57	59	61	100.6
5/21	83	Artillery blast	500	Base	83	85	86	87	88	87	87	90	88	84	88	82	80	75	83	82	84	74	75	73	71	69	68	67	65	62	60	57	54	55	56	57	59	61	98.1
5/21	83	Artillery blast	500	Base	89	91	92	93	91	90	91	93	91	90	90	88	80	78	82	79	79	79	79	76	76	73	71	71	68	66	62	59	56	58	59	60	62	64	102.0
5/21	83	Artillery blast	500	Base	88	90	90	88	89	89	89	88	87	87	91	89	81	77	80	80	76	74	74	72	69	66	64	62	60	57	55	53	52	55	56	57	59	61	99.8
5/21	83	Artillery blast	500	Base	83	85	87	85	85	86	89	92	94	89	84	88	81	75	81	84	84	78	78	76	74	72	72	69	68	65	61	58	55	55	56	57	59	61	100.0
5/21	83	Artillery blast	500	Base	82	86	88	87	87	85	84	86	91	87	88	92	81	76	83	85	85	79	80	78	75	72	70	68	65	63	59	55	53	54	55	57	59	61	99.3
5/21	83	Artillery blast	500	Base	86	83	92	89	89	90	94	95	100	94	97	92	86	85	90	87	88	83	83	84	80	81	79	78	78	77	73	71	68	66	64	62	60	61	105.2
5/21	83	Artillery blast	500	Base	85	88	91	91	89	88	90	92	95	93	92	90	85	83	83	84	83	82	78	77	73	74	71	69	67	64	58	56	53	55	56	57	59	61	102.5
5/21	83	Artillery blast	500	Base	83	87	90	90	91	91	89	88	88	95	93	87	85	82	84	84	87	86	82	79	79	75	74	73	69	67	63	60	56	55	56	57	59	61	102.0
5/21	83	Artillery blast	500	Base	74	77	80	84	87	89	91	91	89	95	94	92	85	85	89	94	91	91	85	84	80	80	82	78	78	77	75	74	72	71	69	67	65	63	102.8
5/21	83	Artillery blast	500	Base	78	83	84	86	85	86	86	88	92	97	93	92	83	79	78	77	77	78	75	74	73	71	69	67	64	60	56	54	52	55	56	57	59	61	101.1
5/21	83	Artillery blast	500	Base	88	90	93	90	90	89	89	91	93	93	91	90	81	78	84	79	83	81	75	73	72	72	71	70	67	64	63	60	56	56	56	57	59	61	102.0
5/21	83	Artillery blast	500	Base	79	82	85	84	85	86	82	82	88	87	85	83	83	77	80	81	78	78	73	71	69	69	66	63	60	57	54	53	52	55	56	57	59	61	96.2
5/21	83	Artillery blast	500	Base	95	98	99	95	95	91	87	89	88	90	88	85	82	80	87	83	85	77	79	74	72	73	71	71	67	66	61	58	56	57	57	59	61	63	104.9
5/21	83	Artillery blast	500	Base	91	94	96	98	94	91	91	90	91	93	94	91	83	84	90	82	80	80	82	78	75	74	71	70	68	64	61	58	54	55	56	57	59	61	104.6
5/21	83	Artillery blast	500	Base	92	95	95	92	91	90	92	93	94	93	90	86	81	81	83	85	83	83	78	76	75	75	73	73	71	69	66	60	58	56	56	57	59	61	103.4
5/21	83	Artillery blast	500	Base	81	84	87	86	84	85	87	87	89	90	89	84	76	75	77	73	71	70	69	68	67	63	61	59	57	53	52	52	51	54	56	57	59	61	97.7
5/21	83	Artillery blast	500	Base	74	78	83	84	86	88	90	92	91	92	91	85	74	74	74	80	76	71	70	69	67	66	63	61	58	55	52	50	49	52	53	54	56	58	99.6
5/21	83	Artillery blast	500	Base	76	79	82	84	86	89	89	92	92	92	92	92	83	75	78	74	76	76	73	72	71	69	68	65	63	61	58	55	53	55	56	57	59	61	100.4
5/21	83	Artillery blast	500	Base	57	65	74	79	82	84	88	93	96	94	94	86	79	75	82	85	79	77	77	76	72	71	70	68	64	63	60	55	51	52	53	54	56	58	101.2
5/21	83	Artillery blast	500	Base	73	81	84	85	84	87	88	88	92	94	92	87	78	79	81	78	78	75	74	72	71	69	68	66	64	60	57	54	51	52	53	54	56	58	99.9
5/21	83	Artillery blast	500	Base	79	82	85	85	83	86	84	86	90	89	88	86	77	75	77	79	80	76	75	72	71	70	68	65	61	59	55	53	52	55	55	57	59	61	97.3
5/21	83	Artillery blast	500	Base	78	83	85	84	82	87	85	92	93	93	89	86	78	77	78	80	76	78	75	73	72	69	67	67	63	59	56	54	52	54	56	57	59	61	99.8
5/21	83	Artillery blast	500	Base	78	83	85	84	82	87	89	92	93	93	89	85	78	77	78	80	76	78	75	73	72	69	67	67	63	59	56	54	52	54	56	57	59	61	99.8
5/21	83	Artillery blast	500	Base	79	83	85	86	85	86	87	89	88	90	89	83	75	77	82	80	78	77	74	74	71	69	70	66	65	60	56	54	52	54	55	57	59	61	97.9

5/21	83	Artillery blast	500	Base	72	81	86	87	87	90	89	92	94	91	83	86	80	82	81	84	79	80	73	75	73	72	70	68	65	64	61	57	54	53	53	54	56	58	100.0
5/21	83	Artillery blast	500	Base	84	89	92	93	91	89	91	92	96	94	92	92	90	82	86	93	91	87	87	88	86	84	82	82	79	77	76	74	71	71	70	69	64	62	104.4
5/21	83	Artillery blast	500	Base	86	89	93	95	94	92	91	92	92	93	91	87	86	81	84	84	84	81	79	78	78	76	76	73	71	67	65	62	58	57	56	57	59	61	103.3
5/21	83	Artillery	500	Base	82	85	86	87	83	83	77	78	72	71	69	69	68	61	57	59	59	59	54	50	50	50	47	49	50	45	51	51	51	55	56	57	59	61	92.9
5/21	83	Artillery	500	Base	87	90	94	95	94	91	91	90	93	90	90	88	89	80	82	86	81	79	79	77	76	76	72	71	69	66	62	58	56	55	56	57	59	61	103.0
5/21	83	Artillery	500	Base	85	88	91	93	92	87	89	92	96	95	94	86	83	81	85	83	84	81	78	78	76	74	73	71	70	67	64	61	59	58	57	58	59	61	103.1
5/21	83	Artillery	500	Base	87	92	95	96	95	92	90	93	94	94	95	89	87	80	84	87	86	83	82	79	78	77	76	75	72	69	67	66	63	62	61	60	60	61	104.5
5/25	83	Tank blast	11800	Base	61	65	68	69	66	63	54	50	47	46	46	43	39	37	35	32	32	30	28	26	25	24	18	25	27	32	40	40	41	32	20	11	14	-1	74.0
5/25	83	Explosion	7500	Base	59	66	69	70	64	62	54	49	55	48	46	42	38	37	34	31	30	28	27	23	26	27	20	24	24	11	17	17	24	28	15		10	-1	74.5
5/25	83	Tank blast	11800	Base	65	70	67	67	65	58	56	51	48	51	43	44	43	40	36	33	32	29	28	27	29	28	21	24	25	21	16	14	28	30	17		13		74.2
5/25	83	Explosion	7500	Base	54	55	54	56	58	55	55	52	49	51	46	47	42	38	36	34	33	31	30	31	32	31	27	25	23		20	20	37	39	21	2	15	2	64.7
5/21	84	Blast	0	Base	51	57	59	54	55	63	60	64	63	61	59	57	63	58	53	50	48	49	49	48	41	35	31	27	24	24	24	24	34	27	16	0	8		71.8
5/21	84	Blast	0	Base	48	59	61	56	63	66	61	62	57	64	67	63	53	51	52	49	47	48	46	45	42	35	30	27	25	18	20	23	33	28	17	-3	8	-3	73.5
4/28	142	25 mm fire	12700	Base	55	53	50	48	44	45	47	48	53	51	48	45	39	29	31	31	32	34	34	32	30	30	26	24	21	1	18	18		13	14		8		61.1
4/28	142	25 mm fire	12700	Base	37	39	37	37	43	50	45	49	53	52	49	45	38	29	29	32	33	34	34	33	31	27	12	21	23		20	18		15	14		9		58.4
4/28	142	25 mm fire	12700	Base	44	42	41	41	48	49	45	44	51	53	46	38	35	29	31	32	34	35	35	33	32	32	30	24	22		18	18		15	14		7		58.1
4/28	142	25 mm	12700	Base	45	49	53	56	57	55	56	55	54	51	44	40	37	28	30	29	27	30	28	20	24	25	11	20	19		17	15		9	14		8		64.2
4/28	142	25 mm	12700	Base	44	41	43	45	48	53	56	55	60	51	48	43	33	26	30	29	29	31	28	22	26	25	17	21	21		16	23	11	12	9		12		64.0
4/28	142	25 mm	12700	Base	34	33	35	42	47	47	51	49	51	45	47	42	40	31	28	27	22	27	25	16	23	23		26	22	19	23	19		13	11		10		57.5
4/28	142	25 mm	12700	Base	38	39	36	42	47	50	53	48	48	46	45	44	37	28	26	27	22	27	25	14	25	24		25	22	10	24	17		7	11		8		58.0
5/22	152	Artillery impact noise	12900	Base	42	44	47	43	44	46	44	54	57	51	47	47	38	37	30	29	26	27	26	21	23	21	21	31	30	22	18	17		29	17		10		60.9
4/20	169	Artillery blast	4100	Base	72	76	80	81	82	82	77	63	58	59	57	53	54	51	49	47	44	42	41	38	40	38	34	33	33	19	23	26		17	24		12		88.3
4/20	169	Artillery blast	4100	Cavity	71	75	79	80	81	80	75	61	54	55	55	56	59	71	67	53	47	42	40	43	42	38	31	36	35	18	29	27		21	22		17		87.0
4/20	169	Artillery blast	4100	Cavity	72	77	80	84	78	77	67	71	69	69	65	65	67	77	68	53	46	40	40	41	39	39	36	37	37	29	32	31		23	24				88.0
4/20	169	Artillery blast	4100	Base	73	78	82	85	80	79	70	76	76	75	70	62	63	57	52	52	47	43	41	37	37	37	29	32	34	21	27	26		19	23		17		89.4
4/23	172	Tank blast	10400	Base	59	56	63	62	57	54	52	48	54	54	49	47	46	44	49	48	46	46	45	39	47	43		41	39		37	31		33	32		28		68.5
4/23	172	Tank blast	10400	Base	67	64	68	69	61	59	58	54	53	53	48	52	50	40	47	45	47	46	46		47	46		43	39		35	33		26	26				74.0
5/19	172	Artillery blast	1800	Base	66	61	69	72	77	75	75	75	73	71	68	65	67	63	62	61	60	59	57	57	55	54	53	52	51	49	48	47	46	45	43	42	40	38	83.7
5/19	172	Artillery blast	1800	Base	66	62	69	72	77	75	75	75	73	71	67	65	67	62	62	60	53	51	47	44	40	36	33	31	35	25	23	21	18	15	12	10	9	7	83.6

5/19	172	Artillery blast	1800	Base	62	64	72	76	79	75	72	68	64	71	70	69	66	64	62	60	60	59	57	56	55	54	52	51	50	49	47	46	45	44	42	41	40	40	83.7
5/19	172	Artillery blast	1800	Base	66	67	71	72	79	72	75	75	72	69	68	68	65	60	65	60	59	59	57	57	55	54	53	52	51	49	48	47	46	44	43	41	40	38	83.7
5/19	172	Artillery Impact noise	12000	Base	58	66	68	69	61	55	52	47	53	47	49	46	39	34	30	29	25	24	24	20	22	21	17	22	21	13	23	16		16	11		9		73.2
5/19	172	Artillery Impact noise	10500	Base	61	67	71	74	65	61	52	47	54	52	48	42	39	35	30	28	26	24	24	21	24	24	15	20	20	-1	17	15	2	16	13		9	-1	76.6
5/19	172	Artillery blast	1800	Base	65	67	70	73	72	74	69	67	69	63	55	52	44	38	32	27	26	24	24	22	23	22	17	23	20	8	19	19	23	20	13		6		80.1
5/19	172	Artillery blast	3600	Base	53	61	66	65	61	68	72	69	68	61	59	55	43	40	30	27	26	25	24	19	22	22	16	21	21	12	26	19	29	18	13		7		77.0
5/19	172	Artillery blast	7200	Base	48	63	68	67	67	64	60	64	58	47	55	50	44	35	31	27	25	24	23	20	23	22	16	21	20	13	17	18	31	25	15		10		73.9
7/14	172	25 mm	10300	Cavity	59		72	68		69	69	63	69	68	67	72	78	70	67	66	59	66	65	60	65	65	55	67	61		57	52		47	49		42		82.5
7/14	172	25 mm	10300	Base	59	41	64	67	33	68	68	66	69	66	65	70	66	65	64	65	61	66	65	58	66	64	49	67	61	38	56	52		46	47		42		79.2
5/20	177	Tank blast/explosion	4000	Base	65	67	68	64	56	47	49	52	48	52	42	46	39	35	33	32	25	29	29	19	27	27	-251	24	23		16	16		14	13		10		72.5
5/20	177	Tank blast/explosion	4000	Base	73	74	75	73	71	61	52	60	60	61	54	51	51	44	39	41	40	41	41	41	40	37	31	32	28	17	24	22	5	17	17	2	13		80.9
5/27	177	Tank blast	4000	Base	56	55	55	57	52	44	43	45	45	44	42	41	41	38	37	37	37	34	31	26	26	23	20	26	41	38	22	24	16	16	16		9		62.8
5/27	177	Tank blast	4000	Base	74	78	79	77	70	66	70	69	64	65	60	59	56	53	49	49	48	47	44	40	37	33	31	27	26	20	21	18	16	15	15	10	11	4	84.1
5/27	177	Tank blast	4000	Base	73	80	79	71	71	73	74	75	71	71	68	67	62	62	65	56	62	58	58	57	56	54	53	52	51	50	48	47	45	44	42	41	39	37	85.4
5/17	179	Tank blast/explosion	9000	Base	79	78	74	67	60	57	56	54	57	53	52	50	48	44	39	41	37	40	38	28	37	37	35	35	32		29	25		23	23		15	12	82.3
5/26	179	Tank blast	9000	Base	84	83	77	69	56	54	55	56	56	53	51	48	45	42	40	38	33	37	34	30	32	33	20	29	26		22	24		20	20		15		86.8
5/26	179	Tank blast	9000	Base	82	83	80	68	60	55	55	59	60	54	55	54	53	46	45	43	38	36	36	29	34	32	21	30	29		23	22		15	23				86.5
5/26	179	Tank blast	9000	Base	81	82	82	78	68	58	61	61	59	59	59	55	53	50	45	42	41	38	36	32	34	35	19	31	29		26	23		19	17		16		87.3
5/21	183	Tank blast	11300	Base	58	63	67	73	78	73	73	73	69	69	72	69	63	64	62	63	60	58	58	57	55	54	53	52	51	49	48	47	46	44	43	42	40	39	83.0
5/21	183	Tank blast	11300	Base	48	49	61	53	51	50	45	42	45	43	38	37	37	32	32	34	36	37	36	34	31	28	22	27	30	46	49	49	44	33	24	18	16	12	63.7
5/4	184	Blast	5000	Base	74	75	73	75	78	75	78	69	62	58	61	59	56	51	48	46	43	41	39	35	32	29	26	24	24	16	20	18	4	14	14	0	11		84.4
5/4	184	Blast	5000	Base	77	80	80	78	77	77	77	67	65	65	62	57	54	49	48	46	45	43	40	37	34	31	26	24	24	16	20	18	8	16	14	6	12	0	86.7
5/4	184	Impact noise	12000	Base	51	55	53	57	61	59	55	54	50	47	45	41	37	34	31	31	27	27	27	20	24	24	7	22	24	9	18	15		25	14		12	0	65.8
6/11	187	Blast	4000	Base	68	74	72	73	71	68	63	60	59	55	51	46	35	31	28	26	26	24	23	20	22	24	22	23	39	35	30	38	32	37	31	26	17	16	79.7
6/11	187	25 mm	12000	Base	56	59	55	55	54	54	53	52	51	47	44	40	35	32	30	29	25	28	26	17	26	25	27	38	45	39	33	45	42	40	38	34	30	24	64.7
6/11	187	25 mm	12000	Base	59	57	52	53	52	50	49	49	50	49	44	41	35	32	30	28	24	28	25	14	26	25	26	32	41	34	33	46	37	43	38	30	27	22	63.7
6/11	187	25 mm	12000	Base	48	50	44	50	46	51	53	56	57	57	51	44	37	31	27	25	24	25	23	20	22	23	20	29	36	31	25	32	37	33	33	28	23	15	63.3
6/11	187	Tank	12000	Base	69	72	67	72	73	70	70	64	58	56	51	47	39	34	27	28	25	23	22	21	22	23	21	26	39	30	23	31	28	30	22	15	16	6	79.4
6/11	187	Tank	12000	Base	86	85	81	78	70	63	66	57	53	51	43	41	37	31	27	27	24	25	22	21	24	22	20	25	39	33	23	39	41	41	33	23	24	20	89.3

6/5	199	Tank blast/explosion	4000	Base	85	82	75	76	81	81	78	74	80	76	77	71	70	70	70	67	68	67	66	64	63	61	60	59	57	56	57	57	56	54	49	48	46	44	90.6
6/5	199			Cavity	87	82	81	79	83	82	79	75	81	76	76	72	75	81	84	73	69	66	65	64	63	61	61	59	58	57	56	55	53	52	51	49	48	46	93.0
6/5	199	Tank blast/explosion	4000	Cavity	82	86	81	74	82	82	80	77	78	79	68	74	73	78	82	77	68	67	64	63	62	61	60	58	57	56	55	53	52	51	49	48	45	42	92.2
6/5	199	Tank blast/explosion	4000	Base	63	86	84	78	83	82	82	80	78	78	71	71	70	70	69	67	67	66	65	64	63	61	60	59	57	56	54	53	51	48	46	43	41	40	91.7
6/5	199	Tank blast/explosion	4000	Base	83	84	81	80	75	81	77	75	78	74	72	72	74	74	70	68	70	69	65	66	73	70	64	63	64	62	61	59	56	55	53	48	46	41	90.6
6/5	199	Tank blast/explosion	4000	Cavity	83	87	83	82	76	79	75	73	76	69	73	70	75	78	82	74	70	71	70	71	67	66	63	66	63	62	61	60	58	57	56	54	52	49	92.2
6/5	199	Tank blast/explosion	4000	Cavity	79	85	82	79	76	79	77	71	75	72	72	73	73	81	85	76	71	66	69	67	67	62	61	61	60	59	57	56	55	54	53	52	52	51	91.8
6/5	199	Tank blast	4000	Base	79	85	81	79	76	78	77	73	75	74	75	76	74	72	69	67	66	67	67	66	64	64	62	60	58	57	55	54	53	52	50	49	48	47	90.1
5/19	216	Artillery blast		Base	46	49	52	54	58	61	64	64	64	67	64	60	58	52	48	46	45	45	45	44	41	39	35	32	28	21	22	21	36	33	20	11	14	7	72.7
5/19	216	Artillery blast		Base	54	69	76	83	81	77	77	75	74	72	75	70	71	65	66	64	64	63	62	60	59	58	57	56	55	53	52	51	50	48	47	45	43	40	87.9
5/19	216	Artillery blast		Base	78	81	83	79	70	64	56	56	62	57	52	50	46	42	35	34	30	27	25	22	24	23	22	33	28	17	25	25	24	29	21		11		87.0
5/19	216	Artillery blast		Base	78	81	82	78	68	63	58	60	63	57	53	50	47	42	37	34	31	27	27	22	24	22	18	22	26	16	18	23	21	28	16		10		86.6
5/19	216	Artillery blast		Base	76	80	82	80	75	72	73	76	75	72	71	71	71	66	57	62	65	59	62	58	58	57	56	54	32	50	47	44	41	40	34	28	25	22	87.8
5/14	218	Tank blast/explosion	7300	Base	56	62	65	65	63	56	49	52	51	45	42	39	38	33	30	30	29	27	25	22	20	19	18	19	21	21	20	21	22	22	23	24	26	27	70.3
5/14	218	Tank blast	7300	Base	57	60	53	59	61	58	50	46	52	48	45	42	39	34	35	30	28	24	22	18	17	16	16	16	17	17	17	17	18	20	20	21	23	24	66.8
5/14	218	Tank blast/explosion	7300	Base	59	63	71	71	68	64	55	53	56	52	48	44	42	39	35	33	31	27	23	22	20	19	19	20	22	21	21	21	21	23	23	24	26	27	75.6
5/14	218	Tank blast/explosion	7300	Base	63	70	71	72	72	66	58	55	57	53	51	47	43	41	39	36	33	29	26	23	22	21	21	22	26	30	24	24	24	25	25	26	27	29	77.9
5/14	218	Tank blast	7300	Base	40	51	54	56	54	50	45	41	40	46	38	42	32	28	26	25	24	21	20	17	16	16	16	20	28	20	26	30	24	23	21	21	23	24	61.0
5/14	218	Tank blast/explosion	7300	Base	65	68	67	66	66	63	54	56	60	53	54	49	42	43	40	35	31	28	23	21	20	19	20	25	27	24	29	27	25	23	23	24	26	27	74.2
5/14	218	Tank blast	7300	Base	45	54	59	60	60	51	48	48	45	47	46	39	35	32	27	25	22	21	19	17	15	16	16	17	23	32	19	22	27	22	21	21	23	24	65.6
5/14	218	Tank blast/explosion	7300	Base	64	65	66	65	63	61	54	53	55	53	52	45	43	40	37	34	29	26	22	21	19	19	18	20	22	20	21	21	23	23	23	24	26	27	72.6
5/21	218	Artillery impact noise	10600	Base	56	57	62	61	59	54	50	48	49	49	47	44	40	38	35	35	35	35	33	32	29	27	18	23	20	-256	15	15	-256	13	12		11		67.1
5/21	218	Artillery impact noise	10600	Base	58	65	66	63	62	58	61	58	58	57	52	49	47	43	39	36	35	33	32	28	27	26	20	23	21	5	18	15	9	16	15		13		71.7
7/14	Church	25 mm	6200	n/a	43	47	51	53	53	54	54	49	45	44	42	36	32	26	28	21	19	17	20	6	25	27	26	33	35	37	35	31	38	24	20		12		61.0
7/15	Church	Tank blast	8800	n/a	81	80	80	78	76	72	73	72	66	64	59	56	54	51	50	48	44	37	33	29	26	25	23	25	27	30	30	24	37	42	45	34	28	17	87.0
5/21	83	Artillery blast	500	Base	87	92	95	96	95	91	89	92	94	92	94	89	84	77	83	81	81	79	79	78	78	76	74	72	71	67	65	62	59	57	57	58	59	61	104.0
5/21	83	Artillery blast	500	Base	82	85	86	84	83	88	91	94	96	96	94	85	83	89	86	86	86	83	81	79	77	78	75	72	69	67	67	63	59	58	57	58	59	61	102.9
5/21	83	Artillery blast	500	Base	86	90	91	90	87	90	92	95	93	93	90	85	80	74	75	76	73	72	71	69	67	66	64	62	59	56	55	54	53	55	56	57	59	61	101.9
5/21	83	Artillery blast	500	Base	84	88	89	90	89	89	92	88	89	83	81	82	77	72	73	75	73	74	70	70	68	66	65	63	61	58	56	55	53	55	56	57	59	61	99.0

5/21	83	Artillery blast	500	Base	84	88	89	89	89	90	93	93	91	91	92	91	83	81	86	86	85	81	78	79	76	74	72	71	70	67	62	62	58	56	56	58	59	61	101.9
5/21	83	Artillery blast	500	Base	89	92	94	93	93	90	91	91	89	89	94	91	85	78	81	78	79	78	75	73	71	71	70	68	63	60	57	54	53	55	56	57	59	61	102.6
5/21	83	Artillery blast	500	Base	84	88	90	91	91	87	90	94	95	93	93	92	83	78	81	80	84	79	77	74	72	71	71	69	65	62	58	55	53	55	56	57	59	61	102.5
5/21	83	Artillery blast	500	Base	86	89	92	93	90	86	81	79	84	84	82	81	78	73	72	72	74	74	74	72	71	71	68	67	66	64	62	60	57	57	56	57	59	61	98.5

Figure E2a. Summary noise data for small arms live fire on Ft. Stewart, GA

0 = no visible response
1 = alert to cavity mouth
2 = flush from cavity

Date	Cluster	Nesting Phase & Day	Event Type	Event Dist. (m)	Azimuth re. DOF	RCW Response	Recovery time (min)	Remarks	Mic Pos.	SEL (dB) at mic Flat	A
29-Apr-98	2	I-6	.50 caliber live fire	5800		0	0		Base	75.1	60.7
29-Apr-98	2	I-6	.50 caliber live fire	5800		0	0		Base	75.9	63.4
29-Apr-98	2	I-6	.50 caliber live fire	5800		0	0		Base	75.8	60.4
19-Jun-98	9	N-20	.50 caliber live fire	8100	55	0	0		Base	59.1	42.1
19-Jun-98	9	N-20	.50 caliber live fire	8100	55	0	0		Base	59.3	41.2
11-May-98	23	I-8	9 mm live fire	1400	155	0	0		Base	57.6	47.6
11-May-98	23	I-8	9 mm live fire	1400	155	0	0		Base	57.2	50.9
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	53.5	39.6
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	49.5	34.2
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	50.0	32.8
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	57.7	41.6
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	50.0	35.5
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	50.2	32.7
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	51.0	35.7
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	52.5	31.5
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	52.6	31.8
30-Apr-98	26	I-7	M-16 live fire	2400	40	0	0		Base	56.2	34.9

06-May-98	26	N-2	9 mm	2600	0	0	0		Base	55.5	36.0
06-May-98	26	N-2	M-16 live fire	3100	20	0	0		Base	60.6	42.4
06-May-98	26	N-2	M-16 live fire	3100	20	0	0		Base	55.4	37.0
06-May-98	26	N-2	M-16 live fire	3100	20	0	0		Base	60.1	43.8
06-May-98	26	N-2	M-16 live fire	3100	20	0	0		Base	52.7	34.4
06-May-98	26	N-2	M-16 live fire	3100	20	0	0		Base	56.2	39.1
05-May-98	51	I-4	M-16 live fire	900	160	0	0		Base	67.5	59.9
05-May-98	51	I-4	M-16 live fire	900	160	0	0		Base	67.4	59.4
05-May-98	51	I-4	M-16 live fire	900	160	0	0		Base	67.1	59.2
14-May-98	133	N-13	7.62 mm gunfire	4000	115	0	0		Base	47.8	40.9
11-Jun-98	187	N-16	.50 caliber live fire	0	55	0	0		Base	56.5	35.3
11-Jun-98	187	N-16	.50 caliber live fire	0	55	0	0		Base	56.4	42.7
11-Jun-98	187	N-16	.50 caliber live fire	0	55	0	0		Base	55.1	40.2
18-May-98	194	N-20	7.62 mm coax	4300	160	0	0		Base	60.2	48.3
18-May-98	194	N-20	7.62 mm coax	4300	160	0	0		Base	75.2	52.8
18-May-98	194	N-20	7.62 mm coax	4300	160	0	0		Base	60.7	52.9

Figure E2b. This sheet contains the representative unweighted noise spectra for small arms live fire on Ft. Stewart, GA.

Date	Col	Event Type	Event Dist. (m)	Mic Pos.	Band SEL (dB) at 1/3 Octave Spectrum Center Frequencies (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	Calc. Overall SEL
4/29	2	.50 caliber fire	5800	Base	55	51	52	60	57	61	68	70	66	66	60	60	55	-221	56	54	51	56	54		49	52	48	51	43		41	42		30	33		30		75
4/29	2	.50 caliber fire	5800	Base	58	51	62	64	66	65	67	71	66	61	57	60	54	50	57	55	55	55	55	52	56	54	51	53	50		41	47		37	38		39		76
4/29	2	.50 caliber fire	5800	Base	51	52	60	63	68	68	67	68	68	62	61	59	57	44	55	55		55	53		52	50	49	51	48		40	43		33	43		30		76
6/19	9	.50 caliber fire	8100	Base	32	41	36	35	42	41	46	53	52	51	52	45	44	39	32	32	31	31	30	28	29	28	26	29	32	26	27	26	21	25	25	21	25	21	59
6/19	9	.50 caliber fire	8100	Base	42	38	38	41	39	43	44	54	52	48	52	47	44	39	33	31	30	29	28	28	27	27	24	27	28	23	26	25	21	25	25	21	25	20	59

5/11	23	9 mm live fire	1400	Base	44	54	42	43	46	46	42	41	40	41	38	39	36	35	35	39	42	45	43	40	38	34	31	28	24	22	18	18	21	20	20	21	23	24	58
5/11	23	9 mm live fire	1400	Base	41	48	41	41	50	46	42	42	38	38	39	38	40	35	37	43	46	47	47	44	40	38	35	34	28	22	19	18	21	20	20	22	23	24	57
4/30	26	M-16 live fire	2400	Base	43	43	41	39	40	42	41	47	43	44	41	37	35	30	32	32	33	32	31	29	31	29	23	25	24	28	27	24	8	18	14		13		53
4/30	26	M-16 live fire	2400	Base	35	45	35	33	34	38	39	39	38	39	35	32	31	26	26	25	24	25	23	17	21	19		19	20	24	28	23	14	21	15		11		50
4/30	26	M-16 live fire	2400	Base	36	46	35	37	38	38	40	37	37	39	35	31	28	22	26	22	20	23	23		22	19		18	18	25	24	22	11	12	11		8		50
4/30	26	M-16 live fire	2400	Base	42	47	48	46	45	53	47	45	47	44	41	37	35	30	32	30	26	31	28	15	27	26	14	25	28	32	34	34	30	20	19		18	-3	58
4/30	26	M-16 live fire	2400	Base	35	40	38	39	37	41	41	34	44	37	34	32	32	25	27	25	24	27	24	20	25	23	19	21	24	29	25	15		10	12		8	-3	50
4/30	26	M-16 live fire	2400	Base	34	38	44	42	39	38	39	40	40	36	35	33	30	24	26	24	21	23	22	11	20	19	16	17	19	26	24	18		11	10		11		50
4/30	26	M-16 live fire	2400	Base	33	35	36	36	47	42	39	41	40	36	36	34	32	28	28	28	27	28	27	26	28	26	22	22	19	24	21	16		9	13		8		51
4/30	26	M-16 live fire	2400	Base	35	38	50	42	37	39	37	39	37	39	37	32	31	29	25	24	19	23	23	14	22	17		18	17	16	23	19	-3	12	12		12		53
4/30	26	M-16 live fire	2400	Base	36	40	50	42	34	41	39	36	36	39	37	31	32	27	25	23	21	22	21	11	21	21	16	19	18	15	23	20	14	11	9		8		53
4/30	26	M-16 live fire	2400	Base	36	41	54	46	39	46	43	41	39	41	42	36	34	30	27	26	23	27	26	18	26	24	13	22	20	18	24	22		12	14		13		56
5/6	26	9 mm	2600	Base	35	34	37	41	42	45	50	52	42	42	35	36	38	34	31	31	29	31	29	22	26	24	10	20	19		17	16		14	16	14	17	12	56
5/6	26	M-16 live fire	3100	Base	39	39	39	42	45	46	50	59	46	48	40	40	41	38	36	35	34	37	37	35	33	30	20	25	25		19	19		17	17		16	-3	61
5/6	26	M-16 live fire	3100	Base	33	40	40	38	41	47	52	47	42	41	40	33	35	35	32	31	32	32	31	28	27	23	12	19	21	19	18	15		12	14	2	10		55
5/6	26	M-16 live fire	3100	Base	42	47	52	54	49	52	50	45	45	47	45	42	42	39	38	37	38	38	38	37	34	31	23	26	26	18	23	19		16	17		16		60
5/6	26	M-16 live fire	3100	Base	36	43	38	40	41	49	41	40	35	38	42	31	31	29	28	29	28	29	28	25	23	23	14	18	18	0	15	13		9	12		9	-3	53
5/6	26	M-16 live fire	3100	Base	38	44	40	41	42	49	52	47	43	42	39	36	36	33	33	33	32	34	34	32	29	27	11	23	20	5	20	17		13	15		13		56
5/5	51	M-16 live fire	900	Base	59		55	61		51			57	53		55	53	53	52	54	55	54	52	43	53	51		46	45		36	41		40	34				67
5/5	51	M-16 live fire	900	Base	58		55	60		56			59	56		55	52		57	52		53	52		52	52	37	48	46		43	44		36	33		37		67
5/5	51	M-16 live fire	900	Base			60	57	48	60	56		57	46		57	52		50	49		51	53		52	50	47	51	45		37	46		39	37				67
5/14	133	7.62 mm gunfire	4000	Base	29	34	35	35	37	39	34	36	33	35	32	31	32	33	32	33	31	31	27	24	24	22	18	22	23	25	28	30	36	33	28	28	30	31	48
6/11	187	.50 caliber fire	0	Base	33	42	43	46	47	48	44	48	49	47	45	37	33	28	26	24	23	25	22		20	21	16	19	18		15	13	29	27	15		10		56
6/11	187	.50 caliber fire	0	Base	38	41	44	46	44	46	45	48	50	46	44	40	35	31	28	27	20	25	24	18	24	23	20	34	34	30	33	34	33	30	22		15		56
6/11	187	.50 caliber fire	0	Base	36	41	43	45	47	47	44	46	47	44	42	39	32	27	25	24	16	23	23	8	21	21	20	31	32	18	25	32	32	33	23	15	16	1	55
5/18	194	7.62 mm coax	4300	Base	40	43	41	45	46	46	51	49	51	54	50	47	46	45	43	42	43	42	42	41	37	35	31	28	28	23	28	28	28	31	32	33	35	37	60
5/18	194	7.62 mm coax	4300	Base	68	65	69	67	61	62	64	62	62	62	59	55	49	49	49	47	47	47	45	44	41	38	35	31	30	27	31	32	32	34	35	36	38	40	75
5/18	194	7.62 mm coax	4300	Base	44	39	36	44	45	45	50	51	49	49	48	46	48	50	47	47	50	47	47	46	43	40	36	32	29	26	27	28	28	31	32	33	35	37	61
5/18	194	7.62 mm coax	4300	Base	71	68	66	69	65	67	65	65	64	61	58	55	49	49	49	48	48	47	45	44	41	38	34	32	31	29	31	31	31	33	35	36	38	40	77

Figure E3b. Summary data for Helicopters on Ft. Stewart, GA.

0 = no visible response
1 = alert to cavity mouth
2 = flush from cavity

Date	Cluster	Nesting Phase & Day	Event Type	Event Dist. (m)	RCW Response	Recovery time (min)	Remarks	Mic Pos.	SEL (dB) at mic Flat	A
30-Apr-98	26	I-7	Helicopter	500	0	0		Base	72.5	55.8
27-Apr-98	48	I-3	Helicopter	300	0	0		Base	97.3	80.9
27-Apr-98	48	I-3	Helicopter	300	0	0		Base	96.3	83.5
21-May-98	62	N-10	Helicopter	190	0	0		Base	101.9	90.9
15-Apr-98	83	Pre-Nesting	Helicopter	200	Pre-nesting	0		Base	97.7	82.1
15-Apr-98	83	Pre-Nesting	Helicopter	200	Pre-nesting	0		Cavity	99.4	89.0
21-May-98	83	I-3	Helicopter	40	1	0		Base	106.3	91.9
21-May-98	83	I-3	Helicopter	200	0	0		Base	98.2	87.7
21-May-98	83	I-3	Helicopter	250	0	0		Base	97.6	87.0
28-Apr-98	142	I-6	Helicopter	500	0	0		Base	78.0	56.6
21-May-98	218	N-21	Helicopter	0	0	0		Base	78.8	59.4
15-Jul-98	Ellabell	n/a	Helicopter	3000	n/a	0		n/a	75.1	61.3
20-May-98	203	N	Helicopter	100	0	0		Base	104.1	93.8

Figure E3b. This sheet contains the representative unweighted noise spectra for Helicopters on Ft. Stewart, GA.

Band SEL (dB) at 1/3 Octave Spectrum Center Frequencies (Hz)

Date	Col	Event Type	Event Dist. (m)	Mic Pos.	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400
4/30	26	Helicopter	500	Base	50	52	62	56	50	62	56	65	63	66	61	60	58	58	56	53	51

Date	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	Calc. Overall SEL
4/30	47	42	35	37	36	28	35	36	37	39	31	27	27	26	10	24	7	72

4/27	48	Helicopter	300	Base	65	71	89	94	76	79	89	76	80	84	81	75	79	77	76	75	75	74	74	74	73	70	66	61	59	51	47	45	30	39	39	27	33	10	97
4/27	48	Helicopter	300	Base	63	72	89	91	74	79	86	78	80	88	83	76	80	78	77	76	75	77	78	77	75	73	69	65	65	58	50	47	37	41	40	21	34	18	96
5/21	62	Helicopter	190	Base	68	73	94	97	80	84	94	83	90	89	87	80	79	77	80	84	87	86	85	82	81	79	78	76	74	71	68	64	61	58	54	42	41	30	102
4/15	83	Helicopter	200	Base	65	71	89	90	80	80	90	82	87	87	90	82	82	79	72	73	75	77	76	74	71	70	66	66	63	50	54	51	-219	46	47		39	27	98
4/15	83	Helicopter	200	Cavity	66	70	87	90	79	75	87	79	83	85	87	81	85	93	95	78	67	68	72	77	76	69	74	75	66	56	56	54	34	47	49		40		99
5/21	83	Helicopter	40	Base	77	80	104	99	80	95	92	89	85	91	82	79	86	86	86	83	83	84	83	82	81	80	79	78	78	76	76	77	78	80	79	77	77	66	106
5/21	83	Helicopter	200	Base	78	77	90	92	77	82	89	79	85	89	86	78	80	75	74	78	82	84	83	80	77	76	74	72	70	67	65	64	64	66	67	69	71	73	98
5/21	83	Helicopter	250	Base	83	83	90	87	79	82	85	79	80	93	83	72	81	79	83	78	80	81	80	79	77	75	74	72	75	71	68	66	65	66	67	69	71	73	98
4/28	142	Helicopter	500	Base	53	52	56	76	57	52	67	58	70	65	66	54	50	50	48	50	54	52	49	45	44	42	31	37	36	34	38	31		26	26		24	4	78
5/21	218	Helicopter		Base	54	55	71	74	55	67	71	65	63	71	63	58	58	56	54	52	53	53	53	52	49	47	43	40	40	29	33	34	29	34	31	21	26	15	79
7/15	Ellabell	Helicopter	3000	n/a	57	66	66	68	69	62	62	62	59	57	54	52	53	55	56	58	56	54	51	47	44	40	36	39	50	49	40	44	56	45	40	31	28	14	75
5/20	203	Helicopter	100	Base	69	77	99	98	80	89	94	83	90	87	88	83	85	87	85	85	86	86	86	85	84	83	82	81	80	79	77	76	76	76	75	67	65	62	104

Figure E4a. Summary data for military vehicle noise on Ft. Stewart, GA.					0 = no visible response 1 = alert to cavity mouth 2 = flush from cavity							
Date	Cluster	Nesting Phase & Day	Event Type	Event Dist. (m)	RCW Response	Recovery time (min)	Remarks	Mic Pos.	SEL (dB) at mic		Lmax (dB) at mic	
									Flat	A	Flat	A
05-May-98	47	N-4	Convoy	60	0	0		Base	95.8	74.1	84.9	61.0
05-May-98	47	N-4	Convoy	60	0	0		Base	96.7	74.9	84.3	61.5
05-May-98	47	N-4	Convoy	60	0	0		Base	83.1	65.9	73.4	55.1
05-May-98	47	N-4	Convoy	60	0	0		Base	90.8	75.4	81.0	67.2
05-May-98	47	N-4	Convoy	60	0	0		Base	81.8	74.1	68.5	60.4
05-May-98	47	N-4	Convoy	60	0	0		Base	92.2	76.0	79.7	60.5
05-May-98	47	N-4	Convoy	60	0	0		Base	76.8	59.9	63.9	49.3
05-May-98	47	N-4	Convoy	60	0	0		Base	99.9	92.0	89.5	81.1

05-May-98	47	N-4	Convoy	60	0	0		Base	95.5	86.6	82.5	83.5
05-May-98	47	N-4	Convoy	60	0	0		Base	106.6	95.0	97.7	84.3
05-May-98	47	N-4	Convoy	60	0	0		Base	78.0	59.6	68.9	45.1
05-May-98	47	N-4	Convoy	60	0	0		Base	92.9	80.3	84.0	64.6
05-May-98	47	N-4	Convoy	60	0	0		Base	84.5	70.3	77.4	62.9
05-May-98	47	N-4	Convoy	60	0	0		Base	90.8	76.5	77.9	63.4

Figure E4b. This sheet contains the representative unweighted noise spectra for military traffic on Ft. Stewart, GA.

Date	Col	Event Type	Event Dist. (m)	Mic Pos.	Band SEL (dB) at 1/3 Octave Spectrum Center Frequencies (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400
5/5	47	Convoy	60	Base	60	63	63	65	69	74	82	88	94	88	76	77	70	67	66	63	58
5/5	47	Convoy	60	Base	58	59	61	66	69	69	76	91	95	86	78	77	72	71	67	64	60
5/14	47	HUMMWVs	30	Base	56	57	57	58	58	63	65	74	78	71	78	73	65	67	62	58	56
5/14	47	2 Hemmits	30	Base	54	54	56	61	63	74	79	71	73	86	88	76	72	67	63	60	57
5/5	51	road 144	400	Base	70		71	68	59	72	69	61	72	70	66	72	69	63	69	68	62
5/21	62	tracked veh	186	Base	58	59	60	64	70	74	79	89	86	79	81	77	69	61	59	60	62
5/20	75	HUMMWV	210	Base	56	56	58	57	56	60	61	68	73	66	69	64	54	48	43	42	42
4/15	83	Military convoy	28	Cavity	59		66	71	75	75	78	80	85	86	87	79	84	93	97	78	67
4/15	83	Military convoy	28	Base	63	57	66	72	75	76	79	81	89	88	89	78	82	83	78	77	73
5/25	83	Tank passes by	26	Base	63	49	67	70	73	81	100	93	83	90	103	95	97	95	84	80	82
4/27	172	HUMMWV	500	Base	73	72	69	68	63	60	61	58	59	62	63	61	52	49	50	51	52
5/26	179	Graders	20	Base	79	79	76	70	68	73	76	86	88	83	82	79	73	70	69	67	63
5/19	216	HUMMWV	15	Base	56	57	57	61	60	61	61	66	77	80	73	76	71	70	71	67	62
5/20	203	Convoy	50	Base	57	59	62	61	66	73	75	77	77	78	81	89	80	65	58	54	54

Date	Col	Event Type	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	Calc. Overall SEL
5/5	47	Convoy	58	59	61	64	63	62	61	58	56	53	52	48	45	42	41	41	42	96
5/5	47	Convoy	60	60	63	65	64	64	61	58	56	53	52	48	45	43	41	41	42	97
5/14	47	HUMMWVs	54	53	52	51	51	51	52	50	47	44	42	42	40	36	36	38	39	83
5/14	47	2 Hemmits	56	60	63	64	65	66	64	62	61	59	54	53	49	42	39	38	39	91
5/5	51	road 144	68	67	57	67	65	52	63	61		56	57		50	52		43		82
5/21	62	tracked veh	64	66	65	66	66	64	66	66	62	58	56	56	52	53	55	56	58	92
5/20	75	HUMMWV	42	42	40	42	42	38	40	38	39	52	52	42	52	53	45	33	21	77
4/15	83	Military convoy	68	72	81	81	75	81	80	72	69	73	68	59	61	58		43	26	100
4/15	83	Military convoy	73	71	73	75	74	79	77	79	70	69	69	64	64	63	60	56	57	95
5/25	83	Tank passes by	78	81	81	82	84	86	84	84	82	80	77	75	74	75	62	53	43	107
4/27	172	HUMMWV	54	54	53	51	48	42	43	42	34	37	34	8	34	32	18	28	10	78
5/26	179	Graders	67	69	71	73	71	71	70	68	66	64	63	59	53	48	31	36	19	93
5/19	216	HUMMWV	58	57	58	57	57	57	57	54	50	47	45	43	42	36	26	27	15	84
5/20	203	Convoy	56	59	64	65	64	64	63	62	60	57	55	51	46	39	37	38	39	91

Figure E5a. Summary data for Artillery Simulators on Ft. Stewart, GA.

0 = no visible response

1 = alert to cavity mouth

2 = flush from cavity

Date	Cluster	Nesting Phase & Day	Event Type	Event Dist. (m)	RCW Response	Recovery time (min)	Remarks	Mic Pos.	SEL (dB) at mic Flat	A
08-Jun-98	37	N-3	Artillery Simulator		0	0		Base	61.6	34.3
14-May-98	86	N-9	Artillery Simulator	2800	0	0		Base	64.1	56.4
14-May-98	86	N-9	Artillery Simulator	2800	0	0		Base	63.9	56.6
14-May-98	133	N-13	Artillery Simulator	4000	0	0		Base	63.3	41.7
19-May-98	172	N-22	Artillery Simulator	6000	0	0		Base	58.9	40.4
19-May-98	172	N-22	Artillery Simulator	6000	0	0		Base	58.8	38.6
21-May-98	172	N-24	Artillery simulator	1600	0	0		Base	74.4	57.1
21-May-98	172	N-24	Artillery simulator	1600	0	0		Base	82.2	72.1
21-May-98	172	N-24	Artillery simulator	1600	0	0		Base	81.3	63.4
14-Jul-98	172	Post-fledging	Artillery Simulator		Post-Fledgling	0		Cavity	82.1	67.5
14-Jul-98	172	Post-fledging	Artillery Simulator		Post-Fledgling	0		Base	80.5	52.9
14-Jul-98	172	Post-fledging	Artillery Simulator		Post-Fledgling	0		Cavity	89.1	61.8
14-Jul-98	172	Post-fledging	Artillery Simulator		Post-Fledgling	0		Base	88.6	44.9
14-Jul-98	172	Post-fledging	Artillery Simulator		Post-Fledgling	0		Cavity	89.8	69.5
14-Jul-98	172	Post-fledging	Artillery Simulator		Post-Fledgling	0		Base	88.9	52.6
14-Jul-98	172	Post-fledging	Artillery Simulator		Post-Fledgling	0		Base	90.3	53.9
14-Jul-98	172	Post-fledging	Artillery Simulator		Post-Fledgling	0		Cavity	92.0	74.3

Figure E5b. This sheet contains the representative unweighted noise spectra for Artillery Simulators on Ft. Stewart, GA.

Date	Col	Event Type	Event Dist. (m)	Mic Pos.	Band SEL (dB) at 1/3 Octave Spectrum Center Frequencies (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	Calc. Overall SEL
6/8	37	Artillery Sim.		Base	52	52	57	55	50	48	49	44	41	41	37	34	30	27	27	25	24	24	23		20	21	15	19	16		14	14	28	29	15		6		62
5/14	86	Artillery Sim.	2800	Base	53	47	54	55		55	54	47	53	49	48	53	49	43	49	48		49	48	35	49	47	42	48	44		39	39		34	28		28		64
5/14	86	Artillery Sim.	2800	Base	51		53	54	42	55	52		53	51	43	55	50		48	49	42	51	49	39	49	49	43	46	45		38	36		28	28		22		64
5/14	133	Artillery Sim.	4000	Base	45	49	52	54	56	56	56	52	49	51	47	42	40	39	35	33	31	30	29	26	26	28	25	27	25	25	27	26	33	32	30	31	33	34	63
5/19	172	Artillery Sim.	6000	Base	42	48	51	50	43	42	40	47	47	50	53	48	36	33	28	26	23	24	24	3	26	25	20	24	22	17	24	22	35	27	18		11		59
5/19	172	Artillery Sim.	6000	Base	39	45	48	50	41	38	36	41	48	53	53	47	36	29	25	23	19	22	22	14	21	19	6	20	19		15	17	29	21	12		6		59
5/21	172	Artillery Sim.	1600	Base	52	53	53	62	61	58	64	67	67	65	65	64	61	55	56	53	53	52	46	44	38	34	28	27	27	24	21	20	28	24	16	9	12	4	74
5/21	172	Artillery Sim.	1600	Base	62	65	65	61	62	59	65	75	76	73	73	67	66	66	69	64	68	65	65	65	64	61	58	56	53	51	50	49	47	47	45	44	43	42	82
5/21	172	Artillery Sim.	1600	Base	45	58	81	62	52	69	54	62	59	65	56	50	53	52	54	54	57	59	59	57	54	51	47	43	38	32	28	26	18	24	21		17	4	81
7/14	172	Artillery Sim.		Cavity	57	67	66	69	71	65	66	63	58	64	71	72	79	73	55	43	39	36	37	36	36	36	31	32	31	26	28	28	21	23	25	13	13		82
7/14	172	Artillery Sim.		Base	59	67	66	70	73	68	73	75	71	63	65	63	51	47	46	43	37	38	36	31	35	33	20	32	29		24	25		18	22		16		80
7/14	172	Artillery Sim.		Cavity	86	84	80	73	59	55	48	47	45	49	51	57	74	65	51	44	40	37	36	37	36	37	31	32	33		28	26		20	22		13		89
7/14	172	Artillery Sim.		Base	86	84	80	73	58	56	52	52	48	50	47	45	44	41	43	42	41	38	37	27	34	32		27	26		26	28		29	35	17	13	10	89
7/14	172	Artillery Sim.		Cavity	85	85	81	73	65	62	65	68	59	60	63	71	82	72	56	46	42	40	40	40	39	40	35	36	36	24	29	30	23	24	23		21		90
7/14	172	Artillery Sim.		Base	85	85	81	73	65	64	66	71	65	63	60	62	56	52	50	46	45	43	40	33	37	37	28	32	32	19	29	28		23	27		18	10	89
7/14	172	Artillery Sim.		Base	86	86	82	76	64	69	75	72	64	58	55	57	57	55	52	51	49	46	45	39	38	37	32	33	31	13	25	22		23	22		16		90
7/14	172	Artillery Sim.		Cavity	86	86	82	76	64	68	73	71	61	60	61	66	87	77	60	51	44	41	39	41	40	40	36	36	37	31	31	31	25	26	27	20	17	16	92

Figure E6a. Summary data for MLRS noise on Ft. Stewart, GA.						0 = no visible response 1 = alert to cavity mouth 2 = flush from cavity					
Date	Cluster	Nesting Phase	Event Type	Event Dist.	Azimuth re. DOF	RCW Response	Recovery time (min)	Remarks	Mic Pos.	SEL (dB) at mic	
20-May-98	75	N-12	MLRS	5600	95	0	0		Base	80.4	47.6
20-May-98	75	N-12	MLRS	5600	95	0	0		Base	80.2	54.1
20-May-98	75	N-12	MLRS	6000	95	0	0		Base	58.4	48.2
20-May-98	203	N	MLRS	2200	160	0	0		Base	82.0	59.0
20-May-98	203	N	MLRS	2200	160	0	0		Base	80.5	58.1

Figure E6b. This sheet contains the representative unweighted noise spectra for MLRS on Ft. Stewart, GA.

Date	Col	Event Type	Event Dist. (m)	Mic Pos.	Band SEL (dB) at 1/3 Octave Spectrum Center Frequencies (Hz)																																		Calc. Overall SEL
					10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	
5/20	75	MLRS	5600	Base	70	73	77	74	68	53	51	48	53	57	51	50	49	46	45	44	44	43	41	37	32	28	23	23	25	19	27	24	24	22	19	19	12	-1	80
5/20	75	MLRS	5600	Base	71	71	75	75	70	59	55	54	58	60	58	58	54	51	50	51	51	50	47	43	39	33	28	27	28	20	27	22		18	17		15		80
5/20	75	MLRS	6000	Base	42	40	44	46	45	43	52	54	45	39	36	33	31	28	29	30	25	29	28	18	28	28	28	34	39	35	39	43	39	37	30	23	20	13	58
5/20	203	MLRS	2200	Base	72	73	67	74	71	74	75	71	65	63	62	62	61	58	54	54	55	53	51	50	48	45	41	36	29	24	23	23	26	26	25	26	28	29	82
5/20	203	MLRS	2200	Base	72	76	65	66	72	69	69	68	64	66	63	61	59	56	52	53	53	51	50	49	48	45	45	39	34	30	27	33	37	29	26	27	28	29	81

Figure E7b. Summary sheet for Airplane data from Ft. Stewart. GA.			0 = no visible response 1 = alert to cavity mouth 2 = flush from cavity						
Date	Cluster	Nesting Phase & Day	Event Type	Event Dist. (m)	RCW Response	Recovery time (min)	Mic Pos.	SEL (dB) at mic Flat	A
15-May-98	51	I-4	Airplane	600	0	0	Base	89.9	78.5
16-Apr-98	83	Pre-Nesting	C-130 Cargo Plane	500	Pre-nesting	0	Cavity	105.7	92.0
16-Apr-98	83	Pre-Nesting	C-130 Cargo Plane	500	Pre-nesting	0	Base	94.7	87.6
20-Apr-98	169	No-nest	Jet	610	non-nesting	0	Cavity	93.4	82.8
20-Apr-98	169	No-nest	Jet	610	non-nesting	0	Base	78.9	67.4

Figure E7b. This sheet contains the representative unweighted noise spectra for Airplanes on Ft. Stewart, GA.

Band SEL (dB) at 1/3 Octave Spectrum Center Frequencies (Hz)

Date	Cal	Event Type	Event Dist. (m)	Mic Pos.	10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500
5/15	51	Airplane	600	Base	54	54	54	55	62	73	62	61	70	76	87	78	68	84	75	79	72	71
4/16	83	C-130 Cargo	500	Cavity	73	68	66	69	73	75	77	79	83	87	91	102	103	89	82	77	75	74
4/16	83	C-130 Cargo	500	Base	73	70	68	72	74	76	78	81	81	82	79	79	85	88	86	83	83	81
4/20	169	Jet	610	Cavity	56	52	57	58	58	59	61	66	70	71	70	78	80	92	86	71	62	57
4/20	169	Jet	610	Base	56	50	58	60	63	64	66	68	70	70	70	65	62	67	70	68	62	58

Date	Cal	Event Type	Event Dist. (m)	Mic Pos.	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	Calc. Overall SEL
5/15	51	Airplane	600	Base	67	64	62	60	59	57	55	52	46	39	33	32	32	24	26	21	90
4/16	83	C-130 Cargo	500	Cavity	78	81	74	75	65	60	59	54	44	41	39	37	39	35	33	32	106
4/16	83	C-130 Cargo	500	Base	80	79	77	76	74	72	68	63	56	47	40	37	39	35	34	31	95
4/20	169	Jet	610	Cavity	55	56	55	54	51	51	51	43	46	45	28	39	40		32	20	93
4/20	169	Jet	610	Base	56	49	53	51	41	48	46	12	41	39		35	37		30		79

Figure E8a. Summary data for blank fire on Ft. Stewart, GA.

0 = no visible response

1 = alert to cavity mouth
2 = flush from cavity

Date	Cluster	Nesting Phase & Day	Event Type	Event Dist. (m)	Azimuth re. DOF	RCW Response	Recovery time (min)	Remarks	Mic Pos.	SEL (dB) at mic Flat	A
03-Jun-98	36	N-2	M-16 blanks	15.2	0	1	0		Base	86.8	86.4
03-Jun-98	36	N-2	M-16 blanks	15.2	0	1	0		Base	85.9	85.7
03-Jun-98	36	N-2	M-16 blanks	15.2	0	1	0		Base	79.0	78.3
03-Jun-98	36	N-2	M-16 blanks	15.2	0	1	0		Base	79.5	79.3
03-Jun-98	36	N-2	M-16 blanks	15.2	0	1	0		Base	79.5	79.1
03-Jun-98	36	N-2	M-16 blanks	15.2	0	1	0		Base	80.4	80.3
03-Jun-98	36	N-2	M-16 blanks	15.2	0	1	0		Base	79.9	79.6
03-Jun-98	36	N-2	M-16 blanks	15.2	0	1	0		Base	79.5	79.1
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	79.4	79.0
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	79.5	79.0
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	80.5	79.7
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	81.0	80.4
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	81.7	81.1
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	79.2	78.6
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	80.1	79.6
03-Jun-98	36	N-2	M-16	15.2	0	0	0		Base	78.8	78.3

			blanks								
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**80.0**	79.6
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**78.4**	77.9
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.0**	78.7
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.3**	78.8
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.8**	79.4
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.5**	79.1
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.1**	78.5
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.4**	78.7
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**80.8**	80.2
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.0**	78.2
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.3**	78.6
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**79.0**	78.3
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**78.5**	77.7
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**78.4**	77.5
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**77.0**	76.0
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**77.3**	76.0
03-Jun-98	36	N-2	M-16 blanks	15.2	0	0	0		Base	**85.7**	84.8
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	**81.2**	79.8
03-Jun-98	37	I-8	M-16	15.2	0	0	0		Base	**81.6**	80.5

			blanks								
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	79.7	78.4
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	81.4	80.0
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	81.2	79.5
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	81.3	79.0
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	80.1	78.9
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	82.9	81.6
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	83.3	81.0
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	81.3	79.3
03-Jun-98	37	I-8	M-16 blanks	15.2	0	0	0		Base	83.8	82.1
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	79.7	78.2
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	81.2	80.8
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	79.5	79.4
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	79.4	78.9
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	79.6	78.4
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	82.1	80.8
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	78.7	77.9
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	79.6	78.7
03-Jun-98	76	N-1	M-16 blanks	15.2	0	0	0		Base	80.7	79.2
03-Jun-98	76	N-1	M-16	15.2	0	0	0		Base	78.6	78.1

			blanks								
10-Jun-98	199	No-nest	M-16 blanks	15.2 front of tree	0	Non-nesting	0		Base	90.0	89.1
10-Jun-98	199	No-nest	M-16 blanks	15.2 front of tree	0	Non-nesting	0		Base	84.3	82.0
10-Jun-98	199	No-nest	M-16 blanks	15.2 front of tree	0	Non-nesting	0		Base	87.1	85.9
10-Jun-98	199	No-nest	M-16 blanks	15.2 front of tree	0	Non-nesting	0		Cavity	93.7	88.5
10-Jun-98	199	No-nest	M-16 blanks	15.2 front of tree	0	Non-nesting	0		Cavity	88.8	83.1
10-Jun-98	199	No-nest	M-16 blanks	15.2 front of tree	0	Non-nesting	0		Cavity	88.3	83.4
10-Jun-98	199	No-nest	M-16 blanks	30.5 behind tree	0	Non-nesting	0		Cavity	80.9	79.6
10-Jun-98	199	No-nest	M-16 blanks	30.5 behind tree	0	Non-nesting	0		Base	78.6	70.9
10-Jun-98	199	No-nest	M-16 blanks	45.7 behind tree	0	Non-nesting	0		Cavity	75.0	66.8
10-Jun-98	199	No-nest	M-16 blanks	45.7 behind tree	0	Non-nesting	0		Cavity	78.5	70.6
10-Jun-98	199	No-nest	M-16 blanks	45.7 behind tree	0	Non-nesting	0		Base	73.0	68.7
10-Jun-98	199	No-nest	M-16 blanks	45.7 behind tree	0	Non-nesting	0		Base	75.2	72.5
10-Jun-98	199	No-nest	M-16 blanks	61 behind tree	0	Non-nesting	0		Base	71.8	63.9
10-Jun-98	199	No-nest	M-16 blanks	61 behind tree	0	Non-nesting	0		Base	72.5	63.9
10-Jun-98	199	No-nest	M-16 blanks	61 behind tree	0	Non-nesting	0		Base	74.1	64.5
10-Jun-98	199	No-nest	M-16 blanks	61 behind tree	0	Non-nesting	0		Cavity	75.2	66.8
10-Jun-98	199	No-nest	M-16 blanks	61 behind tree	0	Non-nesting	0		Cavity	73.5	65.4
10-Jun-98	199	No-nest	M-16 blanks	61 behind tree	0	Non-nesting	0		Cavity	76.2	65.9
10-Jun-98	199	No-nest	M-16	30.5 front	0	Non-	0		Cavit	84.8	76.0

			blanks	tree		nesting			y		
10-Jun-98	199	No-nest	M-16 blanks	30.5 front tree	0	Non-nesting	0		Base	79.9	78.5
10-Jun-98	199	No-nest	M-16 blanks	45.7 front tree	0	Non-nesting	0		Base	82.5	81.5
10-Jun-98	199	No-nest	M-16 blanks	45.7 front tree	0	Non-nesting	0		Cavity	84.1	80.2
10-Jun-98	199	No-nest	M-16 blanks	61 front tree	0	Non-nesting	0		Cavity	81.4	77.2
10-Jun-98	199	No-nest	M-16 blanks	61 front tree	0	Non-nesting	0		Base	78.4	76.9
10-Jun-98	199	No-nest	M-16 blanks	15.2 behind nest	0	Non-nesting	0		Base	83.9	82.9
10-Jun-98	199	No-nest	M-16 blanks	15.2 behind nest	0	Non-nesting	0		Base	79.6	77.9
10-Jun-98	199	No-nest	M-16 blanks	15.2 behind nest	0	Non-nesting	0		Cavity	81.5	75.3
10-Jun-98	199	No-nest	M-16 blanks	15.2 behind nest	0	Non-nesting	0		Cavity	78.7	72.8
03-Jun-98	142	N-22	M-16 blanks	15.2	0	2	5.1333		Base	87.8	87.1
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	76.4	75.3
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.3	79.7
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.7	78.1
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.9	80.1
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	82.8	82.0
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	82.8	82.0
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	76.2	75.3
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	81.1	80.0
03-Jun-98	142	N-22	M-16	15.2	0	0	0		Base	78.4	77.6

			blanks								
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	79.1	77.9
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.8	76.7
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	81.1	80.3
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.9	78.0
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.9	77.9
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.6	77.5
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	76.7	75.9
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.4	79.6
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.3	77.6
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.4	77.5
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.8	79.1
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	82.1	81.1
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.8	76.4
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.1	79.1
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	81.3	80.2
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.9	77.5
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.9	77.8
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	79.6	78.7
03-Jun-98	142	N-22	M-16	15.2	0	0	0		Base	78.2	76.9

			blanks								
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.4	76.1
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.1	75.9
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.4	79.0
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.8	76.6
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.2	76.2
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	79.4	78.3
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.5	76.4
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	81.6	80.4
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	81.3	79.8
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.6	76.5
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	77.7	76.5
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.1	79.5
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	76.7	75.9
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.0	77.1
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.5	79.7
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	81.8	80.5
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.4	77.3
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	78.2	77.2
03-Jun-98	142	N-22	M-16	15.2	0	0	0		Base	81.5	80.1

			blanks								
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	83.1	81.9
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	84.5	83.0
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	80.7	79.2
03-Jun-98	142	N-22	M-16 blanks	15.2	0	0	0		Base	81.0	79.0

Figure E8b. This sheet contains the representative unweighted noise spectra for blank fire on Ft. Stewart, GA.

Date	Cal	Event Type	Event Dist. (m)	Mic Pos.	Band SEL (dB) at 1/3 Octave Spectrum Center Frequencies (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	Calc. Overall SEL
6/3	36	M-16 live fire	15.2	Base	50	48	50	54	57	59	61	64	64	66	67	67	68	69	67	71	68	67	71	77	77	77	79	72	70	73	75	74	73	71	70	71	68	64	87
6/3	36	M-16 live fire	15.2	Base	44	49	47	51	53	57	55	59	61	62	63	63	65	67	65	70	68	66	71	77	77	76	79	71	70	72	73	72	71	71	70	66	66	63	86
6/3	36	M-16 live fire	15.2	Base	42		44	44	48	50	52	55	55	58	58	58	60	62	60	64	63	61	66	70	68	70	71	61	58	63	66	65	63	66	66	63	62	58	79
6/3	36	M-16 live fire	15.2	Base	47	43	42	47	47	51	54	55	55	57	58	58	60	62	59	63	62	59	66	69	67	69	72	62	61	69	70	66	65	65	65	64	61	59	80
6/3	36	M-16 live fire	15.2	Base	44		38	46	46	52	52	55	56	57	58	58	60	61	60	63	62	59	65	69	69	69	72	62	62	67	68	65	67	66	67	65	59	57	79
6/3	36	M-16 live fire	15.2	Base	39		37	45	49	51	53	55	55	57	58	58	61	62	60	64	63	61	65	70	69	69	72	63	65	70	71	68	66	68	64	64	59	54	80
6/3	36	M-16 live fire	15.2	Base	39	37	31	38	34	35	44	53	55	57	58	58	61	62	60	64	63	60	65	70	69	70	72	63	64	67	69	66	66	64	66	64	64	59	80
6/3	36	M-16 live fire	15.2	Base	41	46	41	46	40	48	51	55	55	57	57	58	60	62	59	64	63	60	66	70	69	69	72	60	62	67	66	67	67	67	63	63	63	61	79
6/3	36	M-16 live fire	15.2	Base		39	40	43	49	52	54	55	56	57	57	58	60	62	59	63	62	59	66	70	68	71	70	62	62	68	68	67	67	66	62	64	61	59	79
6/3	36	M-16 live fire	15.2	Base	37	31	44	46	49	52	52	55	55	57	58	58	61	62	60	63	61	59	66	70	68	68	71	60	63	68	68	67	68	65	65	66	62	62	80
6/3	36	M-16 live fire	15.2	Base	55	58	57	54	55	57	60	61	61	62	62	62	63	63	60	63	62	61	66	71	70	72	71	63	64	61	65	68	70	67	64	63	61	60	81
6/3	36	M-16 live fire	15.2	Base	51	52	51	48	49	51	52	55	56	58	59	59	61	62	61	65	64	60	68	70	70	71	72	63	65	69	71	65	66	66	67	68	68	64	81
6/3	36	M-16 live fire	15.2	Base	34	31	38	47	51	54	56	57	58	60	61	61	63	64	61	66	65	62	69	71	69	69	71	67	64	71	71	69	71	70	68	67	67	62	82
6/3	36	M-16 live fire	15.2	Base	42	41	39	46	49	51	53	56	55	57	58	58	60	62	60	64	63	61	65	71	69	71	69	59	62	64	68	65	66	62	64	64	63	59	79
6/3	36	M-16 live fire	15.2	Base	42	37	48	48	46	52	53	54	56	57	58	58	61	62	59	64	62	61	65	71	68	69	69	61	64	69	69	70	67	67	67	66	64	61	80

6/3	36	M-16 live fire	15.2	Base	39		47	49	49	51	53	55	55	57	57	58	61	62	59	63	62	59	65	69	68	68	69	60	64	69	67	65	65	61	64	65	61	57	79
6/3	36	M-16 live fire	15.2	Base	37		44	37	44	49	53	55	55	58	59	60	62	63	60	64	64	60	66	70	70	69	72	63	63	69	69	68	63	64	64	64	63	60	80
6/3	36	M-16 live fire	15.2	Base	44	37	43	46	49	51	53	55	55	57	57	58	60	62	58	63	62	59	65	68	67	68	70	61	61	67	68	66	64	63	60	62	60	57	78
6/3	36	M-16 live fire	15.2	Base	42		43			43	36	33	42	40	55	57	61	62	60	64	63	61	66	70	69	71	71	62	63	66	67	65	64	62	63	61	58	57	79
6/3	36	M-16 live fire	15.2	Base	44		36	38	37	46	49	55	56	58	58	59	61	63	61	64	64	61	66	71	70	70	71	62	60	68	64	64	64	63	63	61	62	58	79
6/3	36	M-16 live fire	15.2	Base	52	47	46	42	49	51	53	55	56	58	58	59	61	62	60	64	64	60	66	69	70	71	72	62	63	66	67	70	66	63	63	63	61	57	80
6/3	36	M-16 live fire	15.2	Base	45	42	42	47	50	52	53	55	56	58	58	59	61	62	60	64	63	60	66	70	69	71	71	61	62	68	66	66	67	63	64	63	62	56	80
6/3	36	M-16 live fire	15.2	Base	42		34	40	36	45	48	54	56	58	58	58	61	62	60	64	63	60	65	71	69	68	70	61	63	67	67	66	63	63	63	62	64	58	79
6/3	36	M-16 live fire	15.2	Base	53	49	51	48	50	52	54	55	56	58	58	59	61	62	60	64	63	61	67	70	70	71	71	60	60	64	63	62	63	67	67	63	61	54	79
6/3	36	M-16 live fire	15.2	Base	44	49	45	41	44	49	51	55	56	58	58	59	62	63	61	65	64	62	67	71	71	71	73	64	62	66	67	67	67	66	68	67	63	60	81
6/3	36	M-16 live fire	15.2	Base		42	39	41	50	52	53	55	56	57	58	59	61	62	60	65	64	61	65	70	70	69	70	59	60	65	65	64	65	66	64	63	63	59	79
6/3	36	M-16 live fire	15.2	Base			42	47	50	50	53	55	55	57	58	59	61	62	60	64	64	61	67	69	69	70	70	59	58	67	67	66	66	69	63	63	62	58	79
6/3	36	M-16 live fire	15.2	Base	47	39	44	43	49	52	55	56	56	58	58	59	61	62	60	64	63	60	66	71	70	70	70	61	60	64	64	64	65	64	65	63	58	57	79
6/3	36	M-16 live fire	15.2	Base	45	47	46	39	50	51	53	55	56	57	58	58	61	62	59	64	63	60	65	69	69	69	68	59	62	65	65	65	65	66	64	63	60	57	78
6/3	36	M-16 live fire	15.2	Base	39		45	45	50	52	54	56	56	58	58	58	60	62	60	63	62	60	65	71	69	70	68	61	60	63	60	64	64	63	62	63	64	60	78
6/3	36	M-16 live fire	15.2	Base	42		42	42	48	51	53	55	54	58	58	57	60	61	59	62	62	59	64	69	67	67	67	59	60	62	61	61	64	61	63	62	61	58	77
6/3	36	M-16 live fire	15.2	Base	37			38	37	41	46	55	55	56	59	58	60	61	58	63	62	59	65	69	67	67	67	57	60	63	60	58	61	63	67	63	63	60	77
6/3	36	M-16 live fire	15.2	Base	44	50	53	55	57	60	62	63	64	65	67	65	67	68	66	70	70	68	73	77	75	76	75	67	68	72	72	71	71	73	73	71	71	67	86
6/3	37	M-16 blank fire	15.2	Base	68	59	65	56		65	67		66	61	59	67	65	62	67	62	64	66	67	70	72	72	74	66	64	65	62	65	60	60	63	60	56	51	81
6/3	37	M-16 blank fire	15.2	Base	59		63	64		56	59		66	64	61	66	64	68	69	64	67	66	68	71	72	71	74	67	65	66	67	66	63	61	62	58	57	51	82
6/3	37	M-16 blank fire	15.2	Base	62		56	56		56	62		64	59	64	66	60	64	67	64	64	65	64	69	70	70	72	63	61	62	64	64	63	63	61	58	56	54	80
6/3	37	M-16 blank fire	15.2	Base	66		61			65	67	65	66	61	54	65	64	66	67	64	63	64	65	70	72	72	73	64	62	66	65	65	64	66	64	62	61	56	81
6/3	37	M-16 blank fire	15.2	Base	68		67	64		67			61	62	58	66	63	65	68	64	63	65	66	70	72	71	72	65	63	63	65	63	63	66	66	64	62	58	81
6/3	37	M-16 blank fire	15.2	Base	64			66		65	66	68	69	67	66	67	65	65	70	65	58	64	64	66	67	72	72	65	66	65	65	66	66	63	63	63	59	53	81
6/3	37	M-16 blank fire	15.2	Base			56	56		62	65		53	63	65	66	63	64	66	65	62	64	66	70	69	70	70	66	65	67	67	66	64	59	61	60	54	52	80
6/3	37	M-16 blank fire	15.2	Base			62	62		68	68	68	65	67	67	68	67	66	72	69	64	65	64	67	64	73	75	73	68	69	67	69	67	65	63	61	57	53	83
6/3	37	M-16 blank fire	15.2	Base			69	62	56	61	64	66	65	69	69	69	67	70	74	71	67	68	69	72	71	64	65	72	72	67	66	70	67	65	63	63	59	54	83
6/3	37	M-16 blank fire	15.2	Base	69			66		67	63		65	67	69	68	63	65	70	67	60	59	64	67	70	72	70	65	67	64	67	68	64	63	57	60	57	52	81
6/3	37	M-16 blank fire	15.2	Base	66					67	65	68	68	70	70	69	67	69	73	70	66	65	67	70	68	70	74	73	72	66	71	68	68	66	65	61	60	56	84

6/3	76	M-16 blank fire	15.2	Base	68	69	61	57	55	49	41	48	53	55	57	57	58	57	57	53	55	61	67	69	69	65	65	60	68	66	67	67	66	65	66	66	66	64	88
6/3	76	M-16 blank fire	15.2	Base	60	56	55	52	52	49	52	52	54	55	56	58	58	56	55	51	56	61	68	70	69	65	65	60	67	69	73	71	70	73	69	67	63	59	81
6/3	76	M-16 blank fire	15.2	Base	53	50	52	52	49	47	51	53	54	56	56	56	57	55	56	52	52	59	64	68	69	66	67	59	68	69	70	71	67	64	65	63	66	60	79
6/3	76	M-16 blank fire	15.2	Base	58	63	58	54	50	54	55	54	55	58	59	59	58	57	59	56	56	57	62	65	66	66	69	60	61	66	68	72	70	68	66	65	65	61	79
6/3	76	M-16 blank fire	15.2	Base	53	51	52	55	55	57	59	60	62	64	64	64	62	61	62	59	56	55	58	59	56	67	69	64	62	65	68	71	70	67	68	66	66	65	88
6/3	76	M-16 blank fire	15.2	Base	51	51	54	51	50	52	55	56	58	60	61	61	61	59	61	59	58	59	63	67	68	68	71	63	64	67	70	72	69	70	72	75	72	66	82
6/3	76	M-16 blank fire	15.2	Base	58	52	50	46	45	49	52	54	56	57	59	59	58	57	59	57	56	57	62	65	67	67	71	63	65	62	66	66	65	64	68	68	67	63	79
6/3	76	M-16 blank fire	15.2	Base	53	56	57	53	52	55	57	59	61	62	64	63	61	57	58	53	51	55	62	65	66	69	69	62	65	64	67	70	69	68	70	67	64	63	88
6/3	76	M-16 blank fire	15.2	Base	61	56	48	51	51	52	52	52	55	57	58	58	58	56	57	56	55	57	62	64	65	67	69	61	59	65	70	70	69	67	72	71	71	70	81
6/3	76	M-16 blank fire	15.2	Base	65	63	58	54	52	52	52	53	54	57	58	58	58	56	58	56	55	56	61	64	65	66	69	60	61	65	71	70	63	65	67	62	61	59	79
6/3	142	M-16 blank	15.2	Base	63			61		65	62	55	61	65	66	66	66	65	66	63	64	71	74	77	74	74	71	67	70	69	72	71	70	72	70	71	70	65	85
6/3	142	M-16 blank	15.2	Base			61	59		63	66	67	62	61	60	66	62	63	64	60	65	68	70	73	70	71	67	63	67	67	70	67	67	67	66	68	68	63	82
6/3	142	M-16 blank	15.2	Base				65		58	59		64	64	60	66	63	64	60	61	62	67	71	74	71	72	67	64	66	63	68	69	67	63	63	67	65	63	81
6/10	199	M-16 live fire	15.2 front of tree	Base	66		68	70		62	66	50	70	66	66	72	69	67	68	66	69	75	77	84	82	78	77	74	75	74	76	77	72	72	76	77	76	72	90
6/10	199	M-16 live fire	15.2 front of tree	Base	72		62	72	56	67	63	66	67	70	68	69	67	65	66	63	66	68	71	76	73	71	70	65	68	69	69	69	67	69	70	69	70	68	84
6/10	199	M-16 live fire	15.2 front of tree	Base	68		69			69	65	68	68	66	65	69	68	68	68	66	68	72	76	78	77	76	76	71	73	69	73	73	71	70	71	74	73	70	87
6/10	199	M-16 live fire	15.2 front of tree	Cavity	66		70	63		64	66	66	71	71	69	71	69	84	91	83	76	70	71	81	79	78	80	70	74	67	65	66	58	62	56	53	56	48	94
6/10	199	M-16 live fire	15.2 front of tree	Cavity			63	56		67	68	67	70	67	66	69	68	79	86	78	72	67	68	75	71	71	74	64	70	65	63	66	59	58	53	49	55	48	89
6/10	199	M-16 live fire	15.2 front of tree	Cavity	67		70	68		65	63		69	70	68	71	68	76	85	79	75	69	68	76	73	71	75	66	69	62	61	64	54	58	54	50	54	47	88
6/10	199	M-16 live fire	30.5 behind tree	Cavity	59		62	60		64	61	58	66	64	65	65	63	62	65	62	58	66	68	70	70	71	71	64	65	64	67	67	66	66	66	66	65	58	81
6/10	199	M-16 live fire	30.5 behind tree	Base	63		63	49		65	61	60	63	61	63	66	67	70	74	63	61	62	63	61	59	57	57	55	52	50	52	48	38	41	42	-220	34	-220	79
6/10	199	M-16 live fire	45.7 behind tree	Cavity	52		61	56		59	56	56	63	58	61	63	62	65	71	61	55	57	59	57	53	52	52	52	50	37	48	46	-222	42	39	-222	-222	-222	75
6/10	199	M-16 live fire	45.7 behind tree	Cavity			56	61	49	63	61	52	61	60	62	63	64	70	76	65	58	59	61	62	57	55	54	50	52	44	49	48	-222	37	41	-222	31	-222	79
6/10	199	M-16 live fire	45.7 behind tree	Base	59		58	57		65	58	52	62	59	56	62	58	57	57	59	56	58	59	60	58	58	58	56	58	57	55	54	52	52	51	50	47	40	73
6/10	199	M-16 live fire	45.7 behind tree	Base			64			62	60		62	60	60	62	61	60	62	60	56	61	63	64	64	64	64	59	57	54	58	58	52	54	57	54	50	38	75
6/10	199	M-16 blank fire	61 behind tree	Base	59		61	60	49	62	57		64	60	50	61	61	54	59	58	56	55	55	53	54	55	54	51	50	31	49	48	-222	40	41	-222	38	-222	72
6/10	199	M-16 blank fire	61 behind tree	Base	65		63	63		63	60		59	54		62	60	-216	60	59	-219	57	55	55	55	55	54	49	48	31	48	47	-222	43	42	-222	34	-222	73

6/10	199	M-16 blank fire	61 behind tree	Base	67		60	60		67	67		61	61		61	60	58	55	58	-208	58	54	-211	59	58	50	52	47	-211	46	42	-211	41	36	-211	31	-211	74
6/10	199	M-16 blank fire	61 behind tree	Cavity	62	58	52	60		61	58		61	57	63	62	63	65	71	60	57	58	55	58	55	56	38	51	49	-222	46	44	-222	41	42	-222	-222	-222	75
6/10	199	M-16 blank fire	61 behind tree	Cavity			49	58		62	60		60	60	57	62	59	64	70	60	56	57	56	53	56	52	-222	51	47	-222	49	43	-222	39	44	-222	31	-222	74
6/10	199	M-16 blank fire	61 behind tree	Cavity	70	63	64	64		63	63	59	65	62	56	65	64	57	67	63	53	60	56	44	57	55	-218	55	53	-218	45	48	-218	43	44	-218	-218	-218	76
6/10	199	M-16 blank fire	30.5 front tree	Cavity	75	78	73	75	69	70	67	65	64	61	65	66	67	71	78	68	66	67	68	67	62	62	62	55	64	63	62	62	47	52	48	40	36	-222	85
6/10	199	M-16 blank fire	30.5 front tree	Base	62		57	63		56	61	60	65	61	62	63	61	58	58	58	60	63	66	70	67	67	69	62	66	68	68	64	63	64	66	67	68	63	80
6/10	199	M-16 blank fire	45.7 front tree	Base	63		67	63		66	63		66	62	63	66	64	59	63	61	62	63	67	71	69	69	72	67	69	69	72	72	69	69	70	69	66	61	82
6/10	199	M-16 blank fire	45.7 front tree	Cavity	58		64	66	55	63	62	55	65	66	64	67	69	73	79	71	69	69	72	75	68	65	68	58	69	67	65	67	56	54	48	39	39	-218	84
6/10	199	M-16 blank fire	61 front tree	Cavity	64		63	61		65	64	61	65	64	64	67	67	72	75	67	64	66	69	73	65	64	65	58	62	60	59	63	49	51	46	31	39	-219	81
6/10	199	M-16 blank fire	61 front tree	Base	64		58	61		59	59	57	65	62	64	66	63	56	61	60	58	61	63	69	66	66	70	65	62	63	65	64	58	61	60	56	56	50	78
6/10	199	M-16 live fire	15.2 behind nest	Base	72		58	63		61	62	56	67		61	66	62	63	64	67	64	66	72	75	76	74	73	69	68	65	68	70	66	67	69	69	67	64	84
6/10	199	M-16 live fire	15.2 behind nest	Base			58	62		59	66		64	49	64	64	63	57	63	64	62	63	68	70	70	68	66	64	63	62	66	65	62	62	63	67	65	60	80
6/10	199	M-16 live fire	15.2 behind nest	Cavity			62	67		55			63	61	64	63	64	72	78	72	67	65	61	67	65	64	62	64	59		52	50			37		37		81
6/10	199	M-16 live fire	15.2 behind nest	Cavity				65		64	65		65	63		64	63	69	74	69	64	61	61	62	63	61	58	65	57		48	45			42				79
6/3	142	M-16 blank	15.2	Base	48	47	52	52	55	57	60	62	63	63	64	64	65	66	64	62	67	73	77	80	77	77	74	70	75	74	75	75	74	74	73	74	74	69	88
6/3	142	M-16 blank	15.2	Base	37	34	36	40	37	39	42	51	52	54	56	56	57	58	56	53	58	64	67	70	66	64	62	56	59	61	63	60	62	62	61	64	60	59	76
6/3	142	M-16 blank	15.2	Base	39	43	45	47	49	52	54	55	57	57	59	58	59	60	59	55	60	66	69	73	68	69	66	58	65	67	70	69	67	66	67	66	66	61	80
6/3	142	M-16 blank	15.2	Base	37	35	41	45	47	49	51	52	54	54	56	55	56	57	56	53	59	65	68	71	66	68	65	59	62	63	70	68	65	65	64	64	65	60	79
6/3	142	M-16 blank	15.2	Base	42	43	44	47	50	52	54	56	56	57	59	59	59	60	59	56	61	67	70	73	70	70	67	59	67	67	70	67	67	67	66	68	68	64	81
6/3	142	M-16 blank	15.2	Base	47	49	48	50	52	54	56	57	58	59	61	60	61	62	61	57	63	68	72	76	72	72	68	62	68	66	71	71	69	67	66	70	69	66	83
6/3	142	M-16 blank	15.2	Base	48	49	48	51	52	54	56	57	58	59	61	60	61	62	61	57	63	68	72	76	72	72	68	62	68	66	71	71	69	67	66	70	69	66	83
6/3	142	M-16 blank	15.2	Base	44	46	39	40	45	48	50	53	53	53	55	55	56	56	55	52	56	62	67	68	64	67	64	56	62	64	59	58	61	61	60	63	64	60	76
6/3	142	M-16 blank	15.2	Base	57	59	51	49	52	52	55	57	57	58	60	60	60	61	61	56	61	67	71	74	70	70	67	59	65	65	68	67	66	65	65	68	69	66	81
6/3	142	M-16 blank	15.2	Base	53	57	52	46	46	48	49	53	54	55	57	57	58	58	57	53	58	64	68	72	68	68	65	57	63	63	65	66	65	62	61	64	64	60	78
6/3	142	M-16 blank	15.2	Base	46	42	45	48	47	50	52	53	54	55	56	56	57	59	58	52	58	63	68	72	68	67	65	55	63	63	63	65	65	68	68	67	65	64	79
6/3	142	M-16 blank	15.2	Base	32	39	41	44	48	50	52	53	54	54	56	56	56	57	56	53	58	63	67	71	67	68	65	57	63	62	63	62	61	60	61	65	66	65	78
6/3	142	M-16 blank	15.2	Base	54	53	54	53	51	53	54	56	57	58	60	59	60	61	61	57	62	67	71	74	70	71	71	60	66	66	66	68	64	63	63	67	67	63	81

6/3	142	M-16 blank	15.2	Base	52	54	49	49	48	51	52	54	55	55	57	57	58	59	58	54	58	64	68	72	69	69	68	57	61	62	65	66	62	62	62	65	64	64	79
6/3	142	M-16 blank	15.2	Base	59	55	58	53	53	51	51	53	55	55	57	57	58	59	59	54	59	64	69	73	69	68	69	58	62	60	62	64	62	61	61	63	66	60	79
6/3	142	M-16 blank	15.2	Base	44	44	49	47	48	50	51	52	54	54	56	55	56	57	57	52	58	64	68	71	68	69	67	58	64	64	61	63	62	65	62	66	67	66	79
6/3	142	M-16 blank	15.2	Base	51	45	44	46	48	49	52	53	54	54	56	55	56	57	56	51	56	63	67	69	63	67	65	55	65	64	59	62	63	62	61	59	64	63	77
6/3	142	M-16 blank	15.2	Base	37	43	45	50	52	54	56	57	58	58	59	59	60	60	59	56	60	67	70	73	70	71	68	60	66	66	65	66	66	64	62	67	65	61	80
6/3	142	M-16 blank	15.2	Base	43	42	46	50	49	53	55	54	55	55	57	56	57	58	57	54	59	65	68	72	69	69	67	56	61	63	65	63	61	62	61	64	63	59	78
6/3	142	M-16 blank	15.2	Base	40	42	46	48	47	52	53	54	56	55	56	56	57	58	57	54	58	64	67	71	68	68	65	55	60	61	65	67	65	64	65	65	64	63	78
6/3	142	M-16 blank	15.2	Base	47	47	47	53	53	55	57	57	57	56	56	55	56	57	57	52	59	63	68	72	69	67	64	60	67	63	61	64	66	71	73	72	70	65	81
6/3	142	M-16 blank	15.2	Base	43	48	49	51	55	56	58	58	59	60	60	60	61	61	61	58	63	68	71	75	71	71	69	61	66	68	69	69	66	69	68	69	70	64	82
6/3	142	M-16 blank	15.2	Base	40	45	45	49	52	52	57	55	56	56	57	58	58	59	58	55	60	66	68	70	66	65	64	55	61	63	62	64	64	65	63	66	64	63	78
6/3	142	M-16 blank	15.2	Base	39	42	47	49	51	54	57	57	58	58	59	59	60	60	59	56	61	66	70	72	68	69	67	59	67	66	67	67	65	66	65	68	68	61	80
6/3	142	M-16 blank	15.2	Base	47	47	52	55	55	57	60	60	61	62	63	62	62	62	60	55	61	66	71	74	70	73	70	60	63	63	65	67	65	65	66	67	69	63	81
6/3	142	M-16 blank	15.2	Base	44	42	37	50	54	58	61	61	62	62	64	63	63	63	62	58	59	63	66	68	62	71	70	62	63	63	64	65	64	62	60	65	65	61	79
6/3	142	M-16 blank	15.2	Base	42	36	46	50	54	55	58	55	54	54	61	62	63	66	64	59	61	65	67	70	65	70	71	60	56	56	60	64	65	64	63	61	62	59	79
6/3	142	M-16 blank	15.2	Base	38	46	51	54	54	58	60	62	63	62	64	63	63	63	63	57	59	61	64	69	64	72	73	63	59	62	61	63	62	64	62	64	62	63	80
6/3	142	M-16 blank	15.2	Base	40	47	49	49	58	57	60	61	61	60	62	61	61	60	59	53	57	62	67	69	64	70	66	56	63	63	63	65	62	65	63	63	65	61	78
6/3	142	M-16 blank	15.2	Base	41	45	44	47	50	49	51	52	55	54	56	56	56	57	57	53	58	64	67	70	67	68	63	56	62	60	60	59	64	61	63	66	67	61	77
6/3	142	M-16 blank	15.2	Base	37	44	50	51	52	57	55	56	58	59	58	58	58	58	58	55	59	64	67	70	67	68	63	57	60	59	63	60	63	62	61	61	62	60	77
6/3	142	M-16 blank	15.2	Base	49	48	51	52	56	58	60	61	63	64	65	65	65	64	63	59	62	68	68	70	61	69	69	66	67	63	64	68	71	66	64	65	64	60	80
6/3	142	M-16 blank	15.2	Base	41	46	48	52	54	57	58	60	61	61	62	61	60	60	59	53	57	64	67	68	63	69	66	60	63	61	65	65	64	63	63	63	62	60	78
6/3	142	M-16 blank	15.2	Base	40	35	36	39	44	48	51	54	54	54	56	55	56	56	55	52	57	64	67	70	66	67	63	54	62	61	64	64	64	66	63	63	64	56	77
6/3	142	M-16 blank	15.2	Base	45	46	49	53	55	56	59	61	62	62	63	63	62	62	62	57	59	64	65	66	62	73	69	62	64	64	66	67	65	64	65	66	65	62	79
6/3	142	M-16 blank	15.2	Base	54	50	43	47	46	50	53	53	55	56	57	56	57	57	57	53	58	64	68	71	67	68	64	57	61	59	61	63	62	63	62	62	66	59	77
6/3	142	M-16 blank	15.2	Base	48	47	51	54	57	59	62	63	64	65	66	66	65	65	64	59	61	65	68	71	68	75	72	63	65	64	65	66	66	67	67	66	65	63	82
6/3	142	M-16 blank	15.2	Base	56	52	54	55	57	59	61	63	64	64	66	65	64	64	64	59	62	67	69	72	66	71	68	63	67	64	67	69	67	68	66	68	69	65	81
6/3	142	M-16 blank	15.2	Base	49	51	48	48	49	48	52	54	55	56	57	57	57	57	57	54	58	65	67	72	68	67	63	57	62	60	63	62	59	60	59	63	63	61	78
6/3	142	M-16 blank	15.2	Base	43	43	41	47	49	51	53	54	55	56	57	56	57	58	58	54	58	64	67	72	68	67	64	57	62	60	60	59	59	62	61	65	64	61	78
6/3	142	M-16 blank	15.2	Base	41	47	50	52	54	56	59	61	62	62	64	62	62	63	63	59	59	61	66	72	68	72	69	66	66	70	66	65	64	61	61	61	59	56	80
6/3	142	M-16 blank	15.2	Base	48	48	49	49	53	56	58	59	60	61	62	60	60	58	57	49	51	59	64	68	67	71	66	56	60	59	55	58	57	56	56	56	55	51	77

6/3	142	M-16 blank	15.2	Base	39	44	45	47	54	56	59	61	62	62	64	63	63	63	62	58	56	59	62	67	63	73	70	62	55	54	58	63	58	57	58	58	60	57	78
6/3	142	M-16 blank	15.2	Base	40	44	46	50	53	55	57	58	59	60	62	61	62	62	63	60	61	65	69	74	71	72	70	65	64	65	62	64	61	63	61	63	62	58	80
6/3	142	M-16 blank	15.2	Base	43	46	53	55	58	60	62	63	65	65	67	67	66	65	64	62	63	67	66	70	64	72	72	63	64	68	69	72	67	67	70	69	65	60	82
6/3	142	M-16 blank	15.2	Base	39	42	48	52	54	56	58	59	61	60	62	60	59	59	58	49	55	63	68	71	68	69	63	55	65	62	66	63	63	62	61	62	64	62	78
6/3	142	M-16 blank	15.2	Base	31	44	48	52	54	57	59	60	61	61	63	62	62	61	60	56	58	62	64	67	64	70	68	61	64	64	65	66	66	64	63	63	62	60	78
6/3	142	M-16 blank	15.2	Base	36	31	37	36	51	55	58	61	63	63	65	65	64	64	63	60	64	69	73	74	70	69	63	62	68	67	67	67	68	65	65	67	67	60	82
6/3	142	M-16 blank	15.2	Base	43	43	48	52	55	57	59	63	65	64	66	65	64	64	63	59	64	69	73	74	70	72	67	63	68	68	71	71	72	69	68	69	70	65	83
6/3	142	M-16 blank	15.2	Base	52	53	54	57	60	62	64	66	67	67	69	68	68	67	67	63	66	72	73	75	72	74	69	70	71	66	70	70	71	72	69	70	70	67	84
6/3	142	M-16 blank	15.2	Base	42	47	50	53	56	58	60	61	63	63	65	64	65	64	64	60	64	70	71	72	69	67	63	67	69	64	67	65	66	65	65	62	65	62	81
6/3	142	M-16 blank	15.2	Base	43	47	50	53	55	57	60	62	63	64	65	65	65	64	64	61	66	71	71	72	69	66	62	65	68	65	63	65	66	63	64	65	69	65	81

Figure E9a. Noise spectra for ambient noise on Ft. Stewart, GA.

Date	Cluster	Nesting Phase & Day	Event Type	Mic Pos.	AVG. LEQ (dB) at mic Flat	A
29-Apr-98	2	I-6	Ambient noise	Base	53.2	41.6
19-Jun-98	9	N-20	Ambient noise	Base	50.3	40.2
11-May-98	23	I-8	Ambient noise	Base	50.7	39.4
30-Apr-98	26	I-7	Ambient noise	Base	46.6	34.0
06-May-98	26	N-2	Ambient noise	Base	46.5	32.3
26-May-98	36	I-5	Ambient noise	Base	63.0	53.5
03-Jun-98	36	N-2	Ambient noise	Base	51.7	43.1
03-Jun-98	37	I-8	Ambient noise	Base	49.9	42.1
08-Jun-98	37	N-3	Ambient noise	Base	45.8	39.1
11-Jun-98	41	N-14	Ambient noise	Base	59.3	49.4

05-May-98	47	N-4	Ambient noise	Base	49.2	37.1
14-May-98	47	N-13	Ambient noise	Base	51.7	35.1
27-Apr-98	48	I-3	Ambient noise	Base	49.8	41.8
27-Apr-98	48	I-3	Ambient noise	Base	48.6	40.3
19-May-98	48	N-13	Ambient noise	Base	53.7	40.1
19-May-98	48	N-13	Ambient noise	Base	52.1	36.6
05-May-98	51	I-4	Ambient noise	Base	52.6	37.7
15-May-98	51	I-4	Ambient noise	Base	49.7	37.3
21-Apr-98	55	N-1	Ambient noise	Base	50.8	42.2
21-Apr-98	55	N-1	Ambient noise	Base	49.6	41.1
27-Apr-98	62	I-2	Ambient noise	Base	48.9	36.1
14-May-98	62	N-3	Ambient noise	Base	53.5	37.9
21-May-98	62	N-10	Ambient noise	Base	54.7	46.0
28-Apr-98	67	I-5	Ambient noise	Base	44.6	30.7
09-Jun-98	67	N-5	Ambient noise	Base	49.1	46.4
20-May-98	75	N-12	Ambient noise	Base	63.6	47.2
03-Jun-98	76	N-1	Ambient noise	Base	55.0	42.4
09-Jun-98	76	N-7	Ambient noise	Base	47.3	35.7
15-Apr-98	83	Pre-Nesting	Ambient noise	Base	54.4	34.4
15-Apr-98	83	Pre-Nesting	Ambient noise	Cavity	56.2	45.2
16-Apr-98	83	Pre-Nesting	Ambient noise	Base	56.3	42.0
16-Apr-98	83	Pre-Nesting	Ambient noise	Cavity	63.0	47.6
20-May-98	83	I-2	Ambient noise	Base	56.7	45.5
21-May-98	83	I-3	Ambient noise	Base	69.0	60.3
21-May-98	83	I-3	Ambient noise	Base	49.7	41.7
25-May-98	83	I-7	Ambient noise	Base	60.6	54.1
25-May-98	83	I-7	Ambient noise	Base	63.2	53.6
25-May-98	83	I-7	Ambient noise	Base	63.9	37.9
21-May-98	84	N-19	Ambient noise	Base	53.0	43.9

14-May-98	86	N-9	Ambient noise	Base	47.2	37.7
14-May-98	133	N-13	Ambient noise	Base	46.9	41.3
28-Apr-98	136	No-nest	Ambient noise	Base	48.0	36.1
28-Apr-98	142	I-6	Ambient noise	Base	48.4	37.1
03-Jun-98	142	N-22	Ambient noise	Base	55.6	41.7
22-May-98	152	N-10	Ambient noise	Base	50.0	36.6
20-Apr-98	169	No-nest	Ambient noise	Cavity	59.6	46.7
20-Apr-98	169	No-nest	Ambient noise	Base	57.9	42.2
23-Apr-98	172	I-6	Ambient noise	Base	60.2	51.3
27-Apr-98	172	N-0	Ambient noise	Base	50.4	39.5
19-May-98	172	N-22	Ambient noise	Base	45.0	35.4
19-May-98	172	N-22	Ambient noise	Base	49.9	43.3
21-May-98	172	N-24	Ambient noise	Base	50.0	36.4
14-Jul-98	172	Post-fledging	Ambient noise	Base	49.6	38.9
14-Jul-98	172	Post-fledging	Ambient noise	Cavity	56.6	44.3
23-Apr-98	174	I-5	Ambient noise	Base	48.6	37.6
20-May-98	177	I-8	Ambient noise	Base	53.2	32.8
27-May-98	177	I	Ambient noise	Base	45.4	31.8
17-May-98	179	N-16	Ambient noise	Base	49.7	42.6
26-May-98	179	0	Ambient noise	Base	48.8	39.3
21-May-98	183	N	Ambient noise	Base	46.5	33.9
04-May-98	184	N-3	Ambient noise	Base	41.7	28.6
11-Jun-98	187	N-16	Ambient noise	Base	51.1	46.2
18-May-98	194	N-20	Ambient noise	Base	48.4	35.2
05-Jun-98	199	No-nest	Ambient noise	Base	51.5	47.9
05-Jun-98	199	No-nest	Ambient noise	Cavity	56.3	43.3
19-May-98	216	N-16	Ambient noise	Base	43.8	37.3
27-Apr-98	218	I-8	Ambient noise	Base	56.8	42.5
14-May-98	218	N-14	Ambient noise	Base	50.2	33.8

21-May-98	218	N-21	Ambient noise	Base	47.5	33.1
14-Jul-98	Buelah	n/a	Ambient noise	n/a	46.8	43.2
15-Jul-98	Buelah	n/a	Ambient noise	n/a	58.9	58.7
20-May-98	203	N	Ambient noise	Base	63.7	45.5

Figure E9b. This sheet contains the representative unweighted spectra for Ambient noise levels on Ft. Stewart, GA.

Date	Col.	Event Type	Mic Pos.	Band LEQ (dB) at 1/3 Octave Spectrum Center Frequencies (Hz) 10	13	16	20	25	32	40	50	63	80	100	125	160	200	250	315	400	500	630	800
4/29	2	Ambient	Base	41	42	44	43	42	42	43	43	43	41	38	34	32	32	27	27	26	28	27	25
6/19	9	Ambient	Base	34	35	36	37	38	38	40	42	42	41	39	35	31	29	29	29	28	29	28	28
5/11	23	Ambient	Base	37	38	40	40	40	41	40	40	38	41	35	34	33	31	29	31	32	34	34	33
4/30	26	Ambient	Base	35	36	35	34	33	37	36	38	37	36	35	32	25	22	23	22	22	22	21	20
5/6	26	Ambient	Base	31	34	36	37	37	35	37	36	36	37	32	28	28	26	24	26	26	26	24	21
5/26	36	Ambient	Base	50		53	50	40	54	52	37	54	52	47	53	51	45	49	48	42	48	46	
6/3	36	Ambient	Base	41	33	39	40	31	41	40	38	41	38	35	40	40	37	38	37	36	37	36	28
6/3	37	Ambient	Base	37	38	38	37	37	40	37	37	39	37	33	33	30	27	31	31	30	32	31	29
6/8	37	Ambient	Base	36	35	36	36	35	34	32	32	34	32	29	30	24	21	25	24	21	23	21	8
6/11	41	Ambient	Base	47		49	48	30	49	49	43	50	47	42	50	47	42	46	44	38	43	43	29
5/5	47	Ambient	Base	39	39	41	40	39	39	38	37	36	36	36	29	26	25	24	23	23	22	22	21
5/14	47	Ambient	Base	37	41	40	41	44	42	43	42	39	42	35	32	32	27	23	20	19	19	19	18
4/27	48	Ambient	Base	39	30	40	39	29	38	41	36	39	36	29	38	35	30	36	35	32	35	34	25
4/27	48	Ambient	Base	37	37	36	36	36	39	38	37	36	34	32	30	29	26	29	29	27	28	26	22
5/19	48	Ambient	Base	34	34	37	40	42	43	47	42	42	46	41	41	38	36	36	33	33	31	32	32
5/19	48	Ambient	Base	31	32	35	39	41	42	44	45	42	43	40	39	36	34	30	27	27	26	27	26
5/5	51	Ambient	Base	36	38	40	41	42	41	43	42	42	46	40	34	31	31	29	28	29	28	27	28

Date	Col.	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000	Calc. Overall LEQ
4/29	2	25	26	27	28	28	29	30	32	32	32	33	33	34	32	53
6/19	9	29	29	28	29	29	26	28	28	26	28	28	27	28	26	50
5/11	23	31	27	24	20	19	18	19	18	20	20	20	21	23	24	51
4/30	26	18	19	19	17	18	25	24	23	23	26	21	21	23	24	47
5/6	26	19	17	15	17	18	16	18	18	18	20	20	21	22	24	46
5/26	36	45	44	38	42	39		40	35		32	34		25	20	63
6/3	36	35	34	26	31	29		26	24		19	21		14		52
6/3	37	29	28	23	28	28	25	30	30	30	32	33	35	37	39	50
6/8	37	20	20	16	21	24	28	27	22	36	31	20	6	9	-8	46
6/11	41	41	40	30	37	35		34	34		30	30		23		59
5/5	47	21	21	20	22	24	23	27	32	28	24	24	25	26	27	49
5/14	47	17	17	17	23	22	21	23	22	30	27	20	22	23	24	52
4/27	48	34	33	26	30	29	13	26	30	-5	17	18		11		58
4/27	48	25	25	22	26	28	30	28	28	30	30	31	33	34	36	49
5/19	48	33	30	25	26	22	16	18	16	10	16	13	1	8	-12	54
5/19	48	28	25	23	22	21	21	19	19	21	21	20	21	23	24	52
5/5	51	27	26	23	22	22	21	23	23	24	26	26	27	29	31	53

5/15	51	Ambient	Base	35	36	35	36	38	43	43	38	38	35	37	29	27	26	27	30	31	32	32	30	28	24	21	19	18	17	18	18	19	20	20	21	23	24	50
4/21	55	Ambient	Base	38	30	38	40	37	41	41	38	41	38	32	39	36	31	36	35	29	36	34	28	35	33	26	34	29		23	22		17	18		13		51
4/21	55	Ambient	Base	38	37	37	38	35	39	38	39	39	36	32	38	34	28	34	34	31	35	34	29	34	32	27	31	28		22	21		15	18		14	0	50
4/27	62	Ambient	Base	36	36	42	39	38	40	39	37	36	35	29	33	30	24	29	28	19	28	27	18	27	26	17	26	25	25	23	20	8	14	14	-7	10	-5	49
5/14	62	Ambient	Base	40	39	42	46	44	43	46	45	42	40	39	34	29	25	25	24	20	24	23	14	23	24	20	24	27	29	26	29	31	20	16	-3	12	-7	54
5/21	62	Ambient	Base	42	42	42	43	41	44	47	43	41	40	38	37	35	31	34	33	27	33	32	28	32	31	27	32	34	32	35	34	34	37	38	40	41	43	55
4/28	67	Ambient	Base	40	36	35	34	32	31	31	29	29	27	22	25	23	19	25	25	23	26	24	19	22	21	11	19	17	-3	13	13	-18	10	10	-8	10	-6	45
6/9	67	Ambient	Base	37	37	35	35	33	34	33	32	32	30	26	26	24	20	24	23	19	25	24	18	22	21	12	22	28	25	37	41	31	41	42	34	26	18	49
5/20	75	Ambient	Base	42	42	41	48	45	48	56	58	55	55	51	52	50	44	40	40	43	39	36	30	28	24	20	26	37	33	26	28	36	37	22	13	14	4	64
6/3	76	Ambient	Base	50	48	46	44	41	41	39	39	38	37	34	34	32	28	31	31	28	32	31	29	30	28	24	28	28	24	31	31	31	33	34	36	37	39	55
6/9	76	Ambient	Base	41	39	36	35	33	33	34	35	36	35	32	28	25	24	29	30	30	30	27	22	23	23	17	21	21	22	20	23	26	23	13	2	17	21	47
4/15	83	Ambient	Base	37	37	41	40	41	45	48	44	47	46	41	35	33	31	30	26	22	25	25	24	26	24	17	20	18	1	14	12	-6	10	10	-8	9	-8	54
4/15	83	Ambient	Cavity	42	41	42	40	40	43	45	42	42	45	38	40	41	47	52	33	26	25	27	34	33	27	29	27	21	4	16	14	-3	10	11		9	-8	56
4/16	83	Ambient	Base	46	41	43	45	41	44	47	51	45	44	43	40	38	33	32	33	33	35	35	34	34	32	28	25	24	22	23	22	21	22	23	25	26	27	56
4/16	83	Ambient	Cavity	54	54	51	49	45	44	46	49	44	46	49	57	56	39	32	30	30	31	38	41	35	36	25	21	22	23	23	20	20	22	23	24	26	28	63
5/20	83	Ambient	Base	41	41	45	44	41	46	45	48	46	47	48	43	37	33	34	33	26	32	31	27	32	31	27	31	32	28	34	34	36	37	37	39	40	42	57
5/21	83	Ambient	Base	62	59	58	57	56	58	54	51	54	52	51	51	49	44	48	47	39	47	46	43	47	46	41	46	47	43	49	49	48	52	53	54	56	58	69
5/21	83	Ambient	Base	38	37	37	36	34	39	36	38	36	34	40	34	32	28	30	29	23	28	27	22	28	27	23	28	28	24	30	30	30	33	34	36	37	39	50
5/25	83	Ambient	Base	48		49	48	33	50	49	44	51	47	41	51	47	42	46	46	40	47	47	37	47	46	36	46	42		34	33	25	25	31		23	8	61
5/25	83	Ambient	Base	49		53	50	46	53	55	52	52	52	46	52	50	45	48	47	41	47	46	38	46	45	33	43	40		37	37		31	30		23	12	63
5/25	83	Ambient	Base	59	58	56	55	52	50	51	43	40	43	39	33	30	27	27	26	26	24	23	22	24	23	21	19	31	21	24	23	30	30	21	23	23	24	64
5/21	84	Ambient	Base	38	40	41	41	40	42	44	42	38	42	44	38	36	31	31	29	27	29	26	21	25	27	23	22	22	19	23	36	42	29	19	10	10	4	53
5/14	86	Ambient	Base	40	39	38	37	35	35	33	33	32	33	31	24	21	20	21	20	18	17	17	16	18	19	20	20	22	21	18	19	32	35	21	24	23	24	47
5/14	133	Ambient	Base	33	34	35	35	35	36	35	35	34	34	30	30	26	25	24	22	15	21	20	16	21	20	17	22	22	25	31	34	34	35	35	30	30	31	47
4/28	136	Ambient	Base	34	34	35	36	36	38	40	39	38	36	31	33	31	26	30	30	26	30	29	23	29	27	11	26	22		18	18	15	14	14		11	-2	48
4/28	142	Ambient	Base	44	40	39	35	34	34	34	33	32	32	29	25	24	24	26	28	30	32	32	30	27	24	21	19	19	19	22	20	19	21	22	24	25	27	48
6/3	142	Ambient	Base	49	49	47	46	44	42	39	41	40	37	35	32	30	27	30	31	32	33	33	31	29	27	23	26	28	25	28	29	31	32	32	33	35	37	56
5/22	152	Ambient	Base	39	38	40	38	44	41	37	37	37	36	35	30	31	27	27	26	23	25	23	17	21	21	17	25	25	22	23	22	30	31	17	-10	9	-7	50
4/20	169	Ambient	Cavity	48	46	49	49	44	49	47	47	48	48	41	40	42	53	47	36	33	31	30	31	31	28	25	27	29	25	29	31	32	35	36	38	38	40	60

4/20	169	Ambient	Base	46	45	49	48	44	48	48	48	47	49	41	38	35	33	31	30	26	29	28	25	28	28	24	28	29	31	30	30	29	32	33	35	37	39	58
4/23	172	Ambient	Base	49	44	51	49		50	48	44	50	46	43	50	47	40	46	45	41	45	44	38	43	42	35	40	37	24	36	34		30	32		22		60
4/27	172	Ambient	Base	45	42	41	39	38	36	37	35	36	35	29	33	30	25	32	33	33	35	34	28	31	29	17	27	27	14	20	18		17	15		9	-7	50
5/19	172	Ambient	Base	35	34	35	35	37	37	33	31	31	28	23	27	24	17	23	22	18	22	21	10	21	21	16	24	29	22	26	27	23	21	14		8	-10	45
5/19	172	Ambient	Base	34	36	39	37	38	39	40	38	39	38	36	37	30	26	24	23	18	23	22	14	21	20	19	28	35	31	32	35	33	39	32	21	18	12	50
5/21	172	Ambient	Base	33	34	36	38	37	38	41	43	43	40	37	34	29	27	24	24	24	23	21	19	17	16	17	23	28	29	27	22	26	23	20	21	23	24	50
7/14	172	Ambient	Base	37	41	39	36	37	38	38	39	39	38	34	32	30	27	28	27	21	26	25	19	24	24	20	25	25	23	27	27	28	30	31	33	34	36	50
7/14	172	Ambient	Cavity	37	40	39	36	36	38	37	37	37	38	40	42	55	47	31	29	26	27	26	24	26	26	22	25	26	22	27	27	27	30	31	33	34	36	57
4/23	174	Ambient	Base	38	36	38	39	35	38	38	37	38	38	36	35	32	23	32	31	26	32	30	24	30	28	19	28	24	-9	22	19		13	15		10	-9	49
5/20	177	Ambient	Base	48	47	46	43	40	37	33	30	32	27	25	24	21	20	22	23	24	25	25	23	22	20	15	17	17	13	19	19	19	21	22	24	26	28	53
5/27	177	Ambient	Base	38	37	36	34	33	34	30	33	35	30	29	29	24	21	21	20	18	19	18	17	17	18	17	17	18	21	23	22	19	20	21	22	23	24	45
5/17	179	Ambient	Base	40	16	38	37		39	37	33	40	36	25	40	37	30	37	35	29	35	35	28	36	35	27	32	30	-3	23	23		17	21		13	-3	50
5/26	179	Ambient	Base	38	33	38	36	24	39	39	36	39	36	32	39	35	26	34	33	28	33	32	22	31	31	19	28	25		24	24		19	22		12		49
5/21	183	Ambient	Base	39	36	35	34	34	34	40	34	34	33	30	30	23	22	23	25	27	27	26	24	21	19	17	17	20	21	21	19	20	24	20	21	23	24	47
5/4	184	Ambient	Base	28	28	32	33	34	32	33	30	29	26	21	26	23	19	23	22	16	22	21	12	21	20	13	18	16	2	15	12		9	9		6	-11	42
6/11	187	Ambient	Base	37	38	38	39	39	40	39	41	40	39	38	33	29	25	25	24	19	22	21	10	21	22	23	27	42	33	29	38	35	35	35	26	23	17	51
5/18	194	Ambient	Base	40	41	39	37	36	35	37	34	37	38	32	33	31	27	26	27	27	26	25	23	21	19	17	17	30	20	20	19	18	19	20	21	23	24	48
6/5	199	Ambient	Base	37	36	43	42	38	37	37	37	38	37	34	31	30	28	29	31	30	32	31	27	29	27	24	34	43	34	26	24	40	42	26	18	20	12	51
6/5	199	Ambient	Cavity	50	47	46	46	43	40	38	35	36	36	40	38	38	45	48	42	32	29	28	22	26	25	18	25	33	26	18	16	5	20	13		8	-6	56
5/19	216	Ambient	Base	30	28	31	32	32	32	31	33	35	33	29	28	25	20	24	24	20	23	21	8	21	20	11	19	20	13	16	17	35	32	18	-11	8	-14	44
4/27	218	Ambient	Base	52	51	48	46	42	41	39	35	39	36	30	38	35	30	36	36	33	38	36	31	35	33	23	30	28		23	22		18	19		13		57
5/14	218	Ambient	Base	36	34	37	39	39	40	41	43	36	37	39	38	36	33	27	25	23	21	22	21	17	17	16	18	21	17	21	24	20	21	20	21	23	24	50
5/21	218	Ambient	Base	39	35	35	37	36	37	37	37	36	35	35	30	28	30	28	27	24	26	25	20	24	23	18	21	20	13	18	17	11	16	15	8	13	6	47
7/14	Buclah	Ambient	n/a	35	37	39	36	33	32	31	30	29	30	27	30	27	20	23	20	17	20	19	10	20	21	24	33	33	34	35	31	38	25	19	4	10	-7	47
7/15	Buclah	Ambient	n/a	39	40	33	37	37	37	35	34	34	33	32	32	27	21	23	21	14	19	19	10	20	20	19	29	32	35	44	58	42	40	47	46	43	33	59
5/20	203	Ambient	Base	51	48	48	48	47	51	57	57	56	54	50	44	43	39	34	32	33	35	36	37	39	37	34	30	27	25	23	22	25	24	21	22	23	24	64